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Final Work Implementation Plan

Catalytic Ozonation of Contaminated Groundwater

July 1998

Prepared for:

**McClellan Air Force Base
Environmental Management**
Contract No. F04699-98-C-0081

URS Greiner
2520 Venture Oaks Way
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AQM01-04-0650

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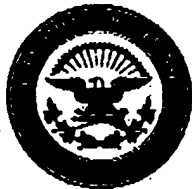
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McClellan Air Force Base, California**JUL 29 1998****MEMORANDUM FOR SEE DISTRIBUTION**

FROM: SM-ALC/EMR
5050 Dudley Blvd, Suite 3
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SUBJECT: Technology Demonstration - Catalytic Ozonation of Groundwater
(DSR Rec. No. 736)

1. Enclosed is the final "Work Implementation Plan; Catalytic Ozonation of Contaminated Groundwater at Site IC 29." This project is being performed by URS Griener with EcoPurification Systems as the primary subcontractor. This demonstration will be conducted at the Investigative Cluster 29/31 Treatment System Innovative Technology Test Pad.
2. This document is record number 736 on the McClellan Document Deliverable Status Report with a due date of 06 August 1998. Comments received to the draft final work plan were incorporated in this document.
3. If you have any questions or concerns, contact Mr. Tim Chapman at (916) 643-0830, ext. 412 or Mr. Kevin Wong at (916) 643-3672, ext. 459.

ELAINE S. ANDEREGG
Remedial Program Manager
Environmental Restoration Division
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Attachment:
Final Work Implementation Plan

cc: McClellan Admin Record

**FINAL REPORT
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Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: McClellan AFB, Kevin Wong				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
1.	3		13-18/24-29	These sentences are similar. Please delete or rewrite either area.
2.	12		8	Please change "receive" to "receiving".
3.	29		27	Please add how the results will aid McAFB personnel in determining compliance with the discharge permit.
4.	36		3	Please change "allow" to "allowed"
				Response
				Lines 24 to 29 will be deleted.
				This will be corrected.
				The sentence will be revised to indicate the demonstration results will be compared to the existing Sacramento County discharge permit limits.
				This will be corrected.

Response to Comments

Final Work Implementation Plan

Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
9.	Figure 12	4.1/ 4.2	-/1-4	Delete Figure 4-1 and lines 1-4 on page 12 as they are repeat other text within the document.
10.	12	4.2	10	Figure 4-4 is the incorrect reference. It appears that this should be figure 4-5. Also, the figure typically is shown immediately after the text in which it is called out, on the next suitable page, or in a section containing all page-size figures.
11.	12/43	4.3/ 8.4		<p>The response to comment 36 was not incorporate within the text. From the PWS</p> <p>2.0 OBJECTIVES:</p> <p>The objectives of this innovative technology demonstration are:</p> <p>2.1 Demonstrate the ability of the ozone system to obtain removal efficiencies and removal rates for (a.) total organics, and (b.) chlorinated organic compounds as functions of inlet concentration, catalyst bed hydraulic residence time, and ozone concentration;</p> <p>2.2 Demonstrate the real-world operating characteristics of a catalyzed ozone treatment system for groundwater pump-and-treat applications;</p> <p>2.3 Quantify the cost and performance data for the catalyzed ozone treatment system under field conditions encountered at McClellan, comparing the capital and operating costs to those of conventional treatment technologies.</p> <p>2.4 Verify that the treated effluent from the system meets applicable regulatory requirements for discharge to publicly owned treatment works and surface waters."</p>
12.	13	4.3	2	Five objectives are referenced and not the four PWS or following objectives.
				These items have been deleted.
				The reference and page order has been corrected.
				The objectives from the PWS has been incorporated throughout the WIP.
				This has been corrected.

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
13.	13	4.3, 4.4	19, 32	The discussion of ozone addition rates do not seem to agree.
14.	13	4.4		While the laboratory test plan is marginally adequate, the work plan should note that since only a single composite sample of liquid is used as the basis for the inlet sampling, the results will be considered suspect and are only for EPS's use in determining recommended field optimization conditions.
15.	Figure	4-5		Figure 4-5 is not adequate for use. The scale of the EPS trailer shown does not seem to be accurate. The test pad and electrical connections on the pad are not shown. Also, the location of the trailer needs to be shown as exactly as possible other technology vendors may be using the remaining space during this demonstration. The utility connections on the trailer do not agree with Figure 5-2. The location and sizing of the water pump is not shown nor is the 264-gallon equalization tank. Piping sizes are not shown on the figure. While the figure does not have to be as detailed as a normal engineering drawing, it should be close enough to reasonably allow for the installation of the equipment.
16.	20	4.5	1-4	This text does not belong in this section. Discussions on the impacts and costs of additional treatment systems should be presented in the appropriate section of the final report.
				The reference to ozone dose in Section 4.3 has been deleted, and a disclaimer added to Section 4.4, reiterating the ozone dose is subject to revision based on analytical results.
				A disclaimer to this effect has been incorporated into this section.
				Figure 4-5 has been corrected to reflect actual dimensions of the trailer, as well as indicate the test pad dimensions, and accurately show the process (influent and effluent water and offgas vent) and utility (potable water, oxygen, electrical, and telephone) points of connection (POC). The corrected figure will indicate the proposed location for the trailer, but has been subject to revision, based on field conditions, and McClellan AFB's requirements. The PE stamp has been removed from the figure. Due to the flexibility designed in to the pilot-scale trailer, locations of the equipment within the trailer and pump sizes are variable, depending on the pilot-scale test requirements (obtained during the laboratory-scale test). Photographs of the equipment layout from another pilot-scale treatment system installation have been included in an appendix.
				These lines have been deleted.

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
17.	20	4.6, 8.0		The discussion on the calculation and statistical evaluation of data presented does not fully respond to Comment 51. Either Section 4.6 or Section 8 needs to address how the data will be evaluated. Based upon the final iteration of the Sampling plan, the appropriate statistical evaluations or the basic methodology for performing the analysis of the data need to be included in the final WIP.
18.	21	5.2		If the pre-heater noted is to be operated during the demonstration, then this should be noted in Sections 4 and 7. The specification or location of the water pump for the system is not included in this section.
19.	Figure	5-1		Figure 5-1 does not provide any useful data that could not otherwise be summarized within the text or included on the revised site layout figure. It does not show the internal layout of the trailer (although that is not necessary) or where the utility, piping, and vent locations are located.
20.	Figure	5-2		Figure 5-2 is not drawn to scale. It does not show where electrical connections will be nor does it show where the vent stack will be located. The connection locations depicted do not agree with Figure 4-5 of the previous section.
21.	23	5.2	1-2	Specify a single proposed location (that is accurately shown on the revised site layout figure). On line 7, the figure 4-5 call out does not appear to be the correct reference.
22.	25/26	5.3	16/14	"URSG and EPS will follow.." While EPS staff may be responsible for operating the system, URSG maintains overall responsibility for compliance with the test plan.
				Response
				Section 4.6 has been amended to indicate a statistical analysis will be conducted to determine whether the data set obtained during the demonstration is normally distributed, first, second, and third order standard deviations will be determined; if the data is not normally distributed, it will be transformed and then first, second, and third order standard deviations determined. In the event the data cannot be normalized, non-parametric statistics will be used to determine the first, second, and third order standard deviations of the data sets.
				The pre-heater is not part of the pilot-scale system. This has been clarified in this and other sections.
				Figure 5-1 has been deleted; additional details have been added to figures 4-2, 4-3, and 5-2.
				Additional details have been added to this figure. Corrections have been made to attain consistency between figures 4-5 and 5-2.
				The proposed location has been shown. The figure reference has been corrected.
				The test has been revised to indicate EPS staff will operate the system under URSG's direction.

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman					Comment	Response
Comment Number	Page	Sect/Para	Line/Sentence			
23.	26/57	5.4/ 9.5.1			Does the ozone generator require LOx or O ₂ gas for operations. The statement for suitable hose used in section 5.4 is adequate if gas will be fed. However, if LOx will be transported in the hose, then the cryogenic and other hazards require that the specific hose grade be called out in the text.	A gas-phase oxygen withdrawal system has been employed. This has been clarified.
24.	27	5.5			Wastewater from sampling will not be poured into the DPE equalization tank. This tank requires a ladder or scaffolding to access. The DPE O&M Manual states that the groundwater and collected rainwater will be pumped into the equalization tank. On line 33 a more generic disposal statement is needed, <i>i.e.</i> , that the material will be shipped to EPS or disposed of as non-hazardous waste. On line 34 add "solid" before waste materials from iron/manganese test kits.	Wastewater generated from sampling has been poured into the effluent holding tank in the pilot-scale trailer, which will then be pumped into the DPE equalization tank. These statements have been corrected. At the conclusion of the pilot-scale test, the used catalyst has been sampled, characterized, and turned over to the McClellan AFB field team for either disposal or reuse. This procedure has been clarified in the WIP. The word "solid" has been added to the description of the waste material from the iron/manganese test kits.
25.	28	5.6			A sentence needs to be added stating that the Field Team will inspect the site following demobilization and verify that it has been restored to the satisfaction of the government.	This sentence has been added.
26.	29	6.1.2			Since the demonstration will run greater than 7 days, it would not be appropriate to cite the SMAQMD pilot-scale exemption.	This reference has been deleted.
27.	31	6.2	1-6		The text should be revised to say that because the effluent from the demonstration system will be treated by the existing system, that there are not any compliance issues. Further, in reference to CWA requirements, the text should indicate that any individual application of the process will need to be evaluated on a case-by-case basis and appropriate surface discharge or other discharge permit requirements met. Text referring to a possible full-scale application should not be used.	These revisions have been incorporated.

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
28.	32	7.1		The data provided from lines 16-20 do not provide sufficient back up information to support the conclusion on line 20. As noted previously, the WIP should state that the data obtained from the laboratory sampling is not intended to provide scientifically defensible data but is for EPS's use in determining target operating parameters for the optimization phase.
29.	33	7.1	32	Add a sentence stating that EPS senior scientific staff will use professional judgment to set determine test conditions based upon the test results. Deviations and rationale for the laboratory test operating parameters will be recorded in the project logbook and summarized in the final report.
30.	Figure	7-3		In Figure 7-3 the figure title is incorrect.
31.		4,5,7		<p>Sections 4, 5, and 7 - Sampling and Analysis/Test Plan - While the Optimization and Operational sampling plan proposed in these sections may be appropriate, the supporting rationale locations is not well enough defined to review. Without this supporting information, the sampling plan is not adequate. Moreover, it appears that the sampling plan will require some modifications to meet the needs of the government. Specifically:</p> <ul style="list-style-type: none"> The choice of 7 days for equilibrium between changes made during optimization is too lengthy (basis - statement is Section 7 saying that 15 residence times should be required for steady state). Fifteen residence times at the longest operational parameter equates to approximately 11.3 hours which is much less than 168 hours proposed. Shortening this time would allow a longer operational period. GAC loading phase - Based on the currently available information for the IC 29 groundwater characteristics and the isotherms generated during the laboratory phase, it should be possible to calculate the approximate time to fully load the GAC. Then only a maximum of 2 sets of VOC
				<p>The Sampling and Analysis/Test Plan has been revised to clarify the sampling locations and rationale. Specific bulleted comments have been addressed as follows:</p> <ul style="list-style-type: none"> The amount of time between changes during the optimization phase has been changed to indicate a maximum of 7 days. Since conditions will not be changed until after receipt of valid analytical results, this maximum interval is based on a "worst-case" scenario of delays in sample transit and analysis, and a subsequent need to collect and analyze another sample. If valid analytical results are received before the end of the equalization period, the conditions will be changed and the additional time added to the operational phase. This clarification has been added. There is a two-fold reason for analyzing 4 sets of samples during the GAC loading phase: 1) verify and calibrate the isotherms developed from the sample collected during the laboratory-scale phase and 2) determine the point at which breakthrough

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
				<p>samples would be needed for verification.</p> <ul style="list-style-type: none"> The need for multiple mid-bed VOC samples per event is not well defined. The total number of mid bed samples in the optimization phase appears excessive. While 3 samples would be needed to provide a meaningful analysis using the t-statistic, it does not seem necessary to perform a statistical analysis on the mid-point samples since the change between influent and effluent is of primary concern. The timing of each of the planned sampling events within the day needs to be explained. In that, how many hours lag will there be between the a, b, and c sample events? Appendix F has an error on page 3, CM+42 showing a QC sample without a corresponding primary sample for E415.2 analysis. Appendix F shows E160.2 (QC) samples without corresponding primary samples. Except for what appears to be a typo for C1-Ic, all QC samples were chosen to be taken on the influent (PI). This is in appropriate and defeats the purpose of having a 10% QA split. The 10% QA samples sent to a second laboratory should be evenly split amongst the samples at various sampling locations and times. When pH is specified, this parameter should be measured on both the influent and effluent port samples. Without further justification, there does not seem to be a need to obtain mid bed samples during the operational phase. The total number of VOC samples in this phase should be increased. Also, since operating conditions will remain the same during the test, taking sample triplets every 14 days is not warranted. Since the destruction/removal efficiency will at worst be evaluated using a one-sided paired t-statistic test, it is not necessary to have triplets to perform a t-test within individual sampling events. This should allow for an evenly spaced set of samples throughout the demonstration, which should provide a much better statistical basis for evaluating the performance of the system. When pH is specified, this
				<p>of the catalyst has allowed effluent concentrations to exceed the target discharge concentrations, but not approach influent concentrations.</p> <ul style="list-style-type: none"> The purpose of the mid-bed VOC sampling in the optimization phase is to identify the adsorption profiles of the catalyst bed. This will have a direct bearing on the full-scale reactor size. Since this information will be an integral part of the final report, its importance cannot be overlooked. Therefore, it is crucial to have a sufficient quantity of data points from the optimization phase to perform a valid statistical analysis. <p>A footnote has been added to the tables in Appendices F and G indicating the "a", "b", and "c" sets of samples have been collected consecutively, approximately 1 hour apart.</p> <p>The error in Appendix F has been corrected so every E415.2 QC sample is associated with a corresponding primary sample. The heading indicating the E160.2 samples are QC samples is incorrect. No QC samples have been analyzed by E160.2.</p> <p>The QC samples will be redistributed amongst samples collected at various locations and times.</p> <p>The pH will be measured at both the influent and the effluent when specified.</p> <ul style="list-style-type: none"> Mid-bed VOC samples will not be collected during the operation phase. These analyses have been used to increase the frequency of influent/effluent sample analyses. <p>The pH will be measured at both the influent and the effluent when specified.</p>

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Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
				<p>parameter should be measured on both the influent and effluent port samples. Appendix G shows E160.2 (QC) samples without corresponding primary samples. Appendix G, CLIN 0005 requirements do not satisfy the requirements of the PWS as modified during negotiations. From the PWS, "3.10 ... Contractor shall perform influent and effluent sampling for the catalyzed ozone system for: (a) total dissolved solids (TDS); (b) pH; (c) alkalinity; (d) ozone; (e) total suspended solids (TSS); (f) biological oxygen demand (BOD5); (g) chemical oxygen demand (COD); (h) trihalomethanes; (i) chlorides, (j) total organics, (k) chlorinated organics, etc. to show compliance with the Clean Water Act (CWA)." It is not appropriate to take the influent and effluent samples on different dates and TSS & pH are not measured at the effluent. Also, one set of 8260A samples will satisfy the requirements for both CLIN 0005 and performance sampling (i.e., performance samples and chlorinated organics from both sections do not need to be duplicated). The total number of CLIN 0005 samples is well below what the government had presented within negotiations. At a minimum, the data obtained from CLIN 0005 samples must be able to be analyzed and a statistical analysis prepared. While the total number of samples may be less than the 33-each proposed by the government in the counteroffer, the value of the data obtained must be of equivalent value to the government. This also holds true for optimization and operation performance sampling for VOCs, etc.</p> <ul style="list-style-type: none"> The use of a 1 minute spigot purge needs to be supported (i.e., how many sample tube volumes). The method of collection of the post-demonstration catalyst sample needs to be expanded. Although an IRPIMS data set is not required, all data should be submitted to the base in electronic format (e.g.,
				<p>The heading indicating the E160.2 samples are QC samples is incorrect. No QC samples will be analyzed by E160.2.</p> <p>The modified CLIN0005 requirements as stated in the PWS have been incorporated into Appendix G. The influent and effluent samples will be collected on the same dates. TSS and pH have been added.</p> <ul style="list-style-type: none"> The description of the purge of the spigot has been revised to indicate approximately 20 ml, which is in excess of 15 volumes, have been purged. The following description of the method for collecting the catalyst sample at the conclusion of the demonstration has been added: <i>"At the conclusion of the demonstration, the top of the reactor has been removed. The catalyst will be vacuumed out and placed in an appropriate container. At three periodic times during this process a sample of the catalyst will be collected. These samples will correspond to the top third, middle third, and bottom third of the reactor. The three samples will be composited to create a representative sample of the spent catalyst for analysis."</i> As indicated in the PWS, the final report will be provided in electronic format. A statement indicating "the analytical results will be summarized on electronic data sheets and included in the final report" will be added to the WIP. <p>The sample handling procedures have been revised to indicate URSG personnel will deliver samples either directly to the laboratory, or to a courier, for transportation to the laboratory (EPS and Gascoyne as the primary laboratories and C&T as the QA/QC laboratory during the</p>

Response to Comments
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Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
				<p>database, spreadsheet, etc.).</p> <ul style="list-style-type: none"> It does not seem possible that URSG personnel will deliver all samples to the appropriate laboratories. Given that EPS samples are taken Maryland and that the 2nd "QA" laboratory was not specified for optimization and operations sampling.
32.	41	8.0		<p>In the introduction to Section 8 it is implied that the EPS laboratory will be in compliance with the requirements of the base-wide QAPP. This section should be reworded to better state what is and what is not in compliance with the base-wide QAPP. Section 8.1 and 8.4 have duplicate titles. Table 8-1 is an incomplete list of analytes required by the PWS.</p>
				<p>laboratory-scale test phase; C&T as the primary laboratory and Air Toxics as the QA/QC laboratory during the optimization/operation phase).</p> <p>EPS has elected to use an alternate laboratory for VOC analysis during the laboratory-scale test, Gascoyne Laboratory, 2101 Van Deman Street, Baltimore, MD 21224, Telephone: (410) 633-1800, Fax: (410) 633-6553. Gascoyne laboratory is an EPA-certified laboratory. As previously noted, the purpose of the laboratory analysis is to develop initial field optimization conditions. Both laboratories (Gascoyne for the VOC analyses and EPS for the remaining analyses) will adhere to industry standards for the analytical methods. However, since these data will not be used to evaluate treatment system performance and efficiency analysis in the final report, they will not attempt to adhere to the requirements of the Base-wide QAPP. This section has been revised to reflect this.</p> <p>The title for Section 8.1 has been changed to "Project-Specific QAPP Requirements".</p> <p>The CLIN0005 requirements have been added to Table 8-1.</p>
33.	42	8.2	8-9	<p>Page 42, lines 8-9 states that C&T will perform the analysis of the 10% split samples from the laboratory. The laboratory that will perform these samples for the optimization and operational phases of the evaluation should also be stated. For clarity, this or another section should clearly address the laboratories to be used in each phase.</p>
				<p>This section (and others) has been revised to indicate C&T will also serve as the primary laboratory for the optimization and operation phases of the demonstration, while Air Toxics will serve as the QA/QC laboratory, analyzing 10% split samples, during these phases.</p>

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman					Response
Comment Number	Page	Sect/Para	Line/Sentence	Comment	
34.	43	8.4	33	Page 43, line 33 " for treating McClellan AFB's extracted groundwater." Also, the list of analytes on lines 34-35 is incomplete.	The word "remediating" has been replaced with "treating". The list of analytes have been expanded to reflect the requirements of CLIN 0005.
35.	Table	8-2		Table 8-2 presents an incomplete listing of analytes that may be found using EPA Method 8260A. Also, the "A" was omitted from the "8260A" in Tables 8-2 and 8-3.	Table 8-2 has been expanded to identify the complete listing of 8260A compounds. The "A" has been added to Tables 8-2 and 8-3.
36.	46	8.4		On page 46, there is a typo "will Heptane also" on line 1 and line 2 should state that PQLs for analytes not presented in Table 8-3 will be according to the Basewide QAPP.	These corrections have been made.
37.	47	8.5.2	25-27	Have all laboratories verified that they will be able to meet the calibration requirements of the Basewide QAPP? On line 31 temperature is listed as a process parameter although it is not included within the SAP. A better explanation and method of calibration should be provided for calibrating flow totalizers (lines 34-37).	All laboratories have verified they can meet the calibration requirements of the Basewide QAPP. However, the lower PQLs requested by the RWQCB will require different calibration requirements, which some labs may be unable to meet. Temperature is not a process parameter and has been removed from the list. A description of calculating the flow rate using a calibrated bucket and stopwatch will be provided.
38.	49	8.6.3	2-3	QA/QC sample results will be presented in the TAAR. CLP or CLP-like data packages do not need to be included in the TAAR.	The clarification has been incorporated.
39.	49	8.7.2		Section 8.7.2 only specifies the 10% splits for the laboratory phase. This section should include the similar explanation for the 2 nd laboratory requirement for the optimization & operation phases.	This section has been clarified.
40.	49	8.7.3		Provide more information or reference specific basewide QAPP procedures for the sample documentation.	A reference to the basewide QAPP has been added.

Response to Comments
Final Work Implementation Plan
Catalytic Ozonation of Groundwater Contaminated With Chlorinated Compounds

Commentor: BDM International, T.E. Chapman				
Comment Number	Page	Sect/Para	Line/Sentence	Comment
41.	53	9.2.3		<p>EPS staff may not be qualified to perform necessary utility hook-ups (e.g., licensed electrician, etc.) Figure 9-1 does not show how the H&S program interfaces with the project organization and does not show the SSC.</p>
42.	59	9.5.1	5-12	<p>The H&S procedures and precautions for the cryogenic hazards associated with LOx are not adequately addressed (Comment 113).</p>
43.	72 and elsewhere			<p>Replace Phil Mook with Kevin Wong.</p>
44.	Appendix J			<p>The map on page 3 of Appendix J does not accurately depict the test pad or seem to be to scale.</p>
				<p>The limitations or EPS Staff's responsibilities for utility connections have been clarified. Figure 9-1 has been revised to show the SSC.</p>
				<p>Additional information or cryogenic hazards associated with LO has been incorporated.</p>
				<p>This replacement has been made.</p>
				<p>The figure has been replaced with one drawn to scale.</p>

**FINAL
WORK IMPLEMENTATION PLAN**

**CATALYTIC OZONATION
OF
CONTAMINATED GROUNDWATER**

**Prepared for:
McClellan Air Force Base
Environmental Management
Contract No. F04699-98-C-0081**

**Prepared by:
URS Greiner, Inc. - California**

July 1998

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ABBREVIATIONS AND ACRONYMS

AAR	Application Analysis Report
AFB	Air Force Base
AFBCA	Air Force Base Conversion Agency
AOP	Advanced oxidation process
bgs	Below ground surface
BOD5	Biological oxygen demand (5-day)
BTEX	Benzene, toluene, ethylbenzene, total xylene
CAA	Clean Air Act
CARB	California Air Resources Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGI	Combustible gas indicator
Cl ⁻	Chloride
CO ₂	Carbon dioxide
COC	Chain-of-custody
COD	Chemical oxygen demand
CSF	Conforming storage facility
C&T	Curtis & Tompkins
CWA	Clean Water Act
dBA	Decibels A scale
DCA	Dichloroethane
DCE	Dichloroethene
DHS	Department of Health Services
DoD	Department of Defense
DQO	Data quality objectives
DPE	Dual phase extraction
DRIs	Direct reading instruments
DTSC	Department of Toxic Substance Control
EC	ECOCHOICE®
EPA	U.S. Environmental Protection Agency
EPS	ECO Purification Systems USA
EM	Environmental Management
eV	Electronvolt
Fe	Iron
FID	Flame ionization detector
FIFRA	Federal Insecticide, Fungicide, Rodenticide Act
FOC	Field operations coordinator
GAC	Granular activated carbon
GHT	Garden hose thread
GWTP	Groundwater Treatment Plant
H ₂ O	Water
H&S	Health and safety
HEPA	High Efficiency Particulate Air
HSP	Health and Safety Plan
HVDPE	High Vacuum Dual Phase Extraction
ID	Identification

ABBREVIATIONS AND ACRONYMS (Cont'd)

IDLH	Immediately dangerous to life or health
IP	Ionization potential
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Information Management System
ITP	Innovative Technology Program
IWL	Industrial waste line
IWTP	Industrial Wastewater Treatment Plant
LEL	Lower explosive limit
LGAC	Liquid-phase granular activated carbon
LO _x	Liquid oxygen
LVDPE	Low Vacuum Dual Phase Extraction
MCLs	Maximum contaminant levels
MDLs	Method detection limits
METRIC	McClellan Environmental Technology Remediation Implementation Contract
min	minutes
µg/L	Micrograms per liter
mg/L	Milligrams per liter
ml	milliliter
Mn	manganese
MSDS	Material safety data sheets
NAPL	Non-Aqueous Phase Liquids
NEMA	National Electrical Manufacturers Association
NETTS	National Environmental Technology Test Site
NIOSH	National Institute of Occupational Safety and Health
NMOCs	Non-methane organic carbons
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
OSHA	Occupational Safety and Health Act
OU	Operable unit
O ⁻	Oxygen radical
O ₂	Oxygen
O ₃	Ozone
OH ⁻	Hydroxyl radical
O&M	Operation and Maintenance
PCE	Tetrachloroethene
PELs	Permissible exposure limits
PE	Performance Evaluation
PE	Professional Engineer
PID	Photoionization detector
PIP	Photoionization potential
PM	Project Manager
ppb	Parts per billion
ppbv	Parts per billion by volume
PPE	Personal protective equipment
ppm	Parts per million
PRDA	Program Research and Development Announcement
PWS	Project work statement

ABBREVIATIONS AND ACRONYMS (Cont'd)

PVC	Polyvinyl chloride
QA	Quality assurance
QAO	Quality assurance objectives
QAPP	Quality assurance project plan
QC	Quality control
RAWP	Removal Action Work Plan
RCRA	Resource Conservation and Recovery Act
RWQCB	Regional Water Quality Control Board
SDWA	Safe Drinking Water Act
SERDP	Strategic Environmental Research and Development Program
SHSP	Site-Specific Health and Safety Plan
SM	Site Manager
SMAQMD	Sacramento Metropolitan Air Quality Management District
SOP	Standard operating procedure
SSC	Site safety coordinator
STEL	Short-term exposure limit
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TAAR	Technology Application Analysis Report
TCA	Trichloroethane
TCE	Trichloroethene
TDS	Total Dissolved Solids
THM	Trihalomethanes
TOC	Total organic carbon
TSCA	Toxic Substances Control Act
TSS	Total suspended solids
TWA	Time-weighted average
URSG	URS Greiner, Inc. - California
USC	United States Code
UST	Underground storage tank
UV	Ultraviolet
UV/Ox	Ultraviolet/oxidation
VC	Vinyl chloride
VOA	Volatile Organic Analysis
VOC	Volatile organic compound
WIP	Work Implementation Plan
°C	Degrees centigrade

1.0 INTRODUCTION AND BACKGROUND

This section introduces the innovative technology demonstration of the ECOCHOICE® (EC) catalytic ozonation system for the ex situ degradation and removal of chlorinated solvents from contaminated groundwater. The demonstration is being conducted by URS Greiner, Inc. - California (URSG) and ECO Purification Systems USA (EPS) for McClellan Air Force Base (AFB) with funding from the Air Force Base Conversion Agency (AFBCA) under a McClellan Contract issued through the Program Research and Development Announcement (PRDA) process. This section describes the technology need that was identified by McClellan AFB, a National Environmental Technology Test Site (NETTS), and discusses how the EC demonstration is being conducted.

1.1 PROGRAM OVERVIEW

The Innovative Technology Program (ITP) conducts demonstrations in support of the McClellan AFB Installation Restoration Program (IRP). The technologies evaluated by McClellan AFB at the NETTS location are chosen because they have the potential to accelerate the IRP program or reduce the overall clean up cost for the base. This technology was identified and selected through a PRDA issued by the ITP.

McClellan AFB is one of five national NETTS with established infrastructures and well-characterized contamination. The goal of the NETTS program is to establish federal test locations at federal sites where governmental and private organizations can be invited to rigorously test and evaluate new environmental control and remediation technologies. The test program at each location is designed to obtain realistic environmental and economic information that may be applied nationwide to support the adoption and use of the more successful technologies.

1.2 TECHNOLOGY NEED

To date, over 250 waste sites, potential release locations, and other areas that warranted investigation have been identified at McClellan AFB. These have been grouped into eleven operable units (OUs) each corresponding to an area at McClellan AFB where specific industrial operations or waste management activities have taken place.

Groundwater and soil samples collected on and in the vicinity of McClellan AFB have shown the presence of a variety of contaminants, principally volatile organic compounds (VOCs) and metals. Eleven contaminants have been consistently detected in the groundwater at concentrations exceeding federal drinking water standards: benzene, carbon tetrachloride, chloroform, 1,2-dichlorobenzene, 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), cis- and trans-1,2-DCE, trichloroethene (TCE), tetrachloroethene (PCE), and vinyl chloride (VC).

Groundwater contaminants have been detected in the shallow, intermediate, and deep aquifers underlying McClellan AFB. The contaminant having the greatest spatial extent is TCE; for all contaminants, contamination underlying an area of approximately 966 acres exceeds a 1×10^{-6} excess cancer risk; groundwater with contaminant plumes exceeding background underlies 1,570 acres. Soil contamination at McClellan AFB constitutes the source for groundwater contamination. McClellan AFB selected a URSG/EPS proposal to demonstrate the application of the ex-situ EC catalytic ozonation for the treatment

- 1 of groundwater contaminated with VOCs. The EC technology has promise for providing cost-effective
- 2 treatment of contaminated streams anticipated at McClellan AFB (Kaptijn, et al. 1994; Kaptijn 1997).

3 **1.3 AMENDMENTS AND MODIFICATIONS**

4 **RESERVED**

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

McClellan AFB is located approximately seven miles northeast of downtown Sacramento, California (Figure 2-1). Because of current and past missions, McClellan AFB has engaged in a variety of operations involving the use, storage, and disposal of hazardous materials including industrial solvents, caustic cleaners, electroplating chemicals, heavy metals, polychlorinated biphenyls, low-level radioactive materials and a variety of fuel oils and petroleum hydrocarbons.

In the late 1970s, groundwater contamination was discovered at McClellan AFB; subsequent studies identified past waste disposal activities as the likely source of this contamination. VOCs constitute the most widespread and common subsurface contaminants at McClellan AFB.

The site selected for the EC demonstration is Site IC 29. The site selection was made based on a review of available data, follow-up discussions with McClellan AFB personnel, and a physical inspection of each of four potential sites. This site was selected as the most promising because the contaminants contained within the waste streams were of the widest range and therefore the results of the demonstration could be better extrapolated to future applications at McClellan and elsewhere nationwide. Appendix A contains a spreadsheet of the data available on all sites. These potential sites included: three stand-alone aqueous-phase granular activated carbon (GAC) units located in the southeast corner of the base in OU A, the groundwater treatment plant (GWTP) on the west side of the base in OU C, and the dual-phase extraction (DPE) system located at IC 31 treating groundwater from wells in IC 29 in OU A. On the basis of a physical inspection of the sites, the OU A GAC sites were eliminated on the basis of logistics; the remaining two sites, the GWTP and the DPE, were identified as the potential candidates for the EC demonstration. These two sites were selected as the most promising sites because of the contaminants contained within their waste streams, and the results of the demonstration could be better extrapolated to full-scale applications at McClellan AFB. Furthermore, from a potential full-scale installation perspective, these were the only two sites that had any potential of having a new technology system installed in the future.

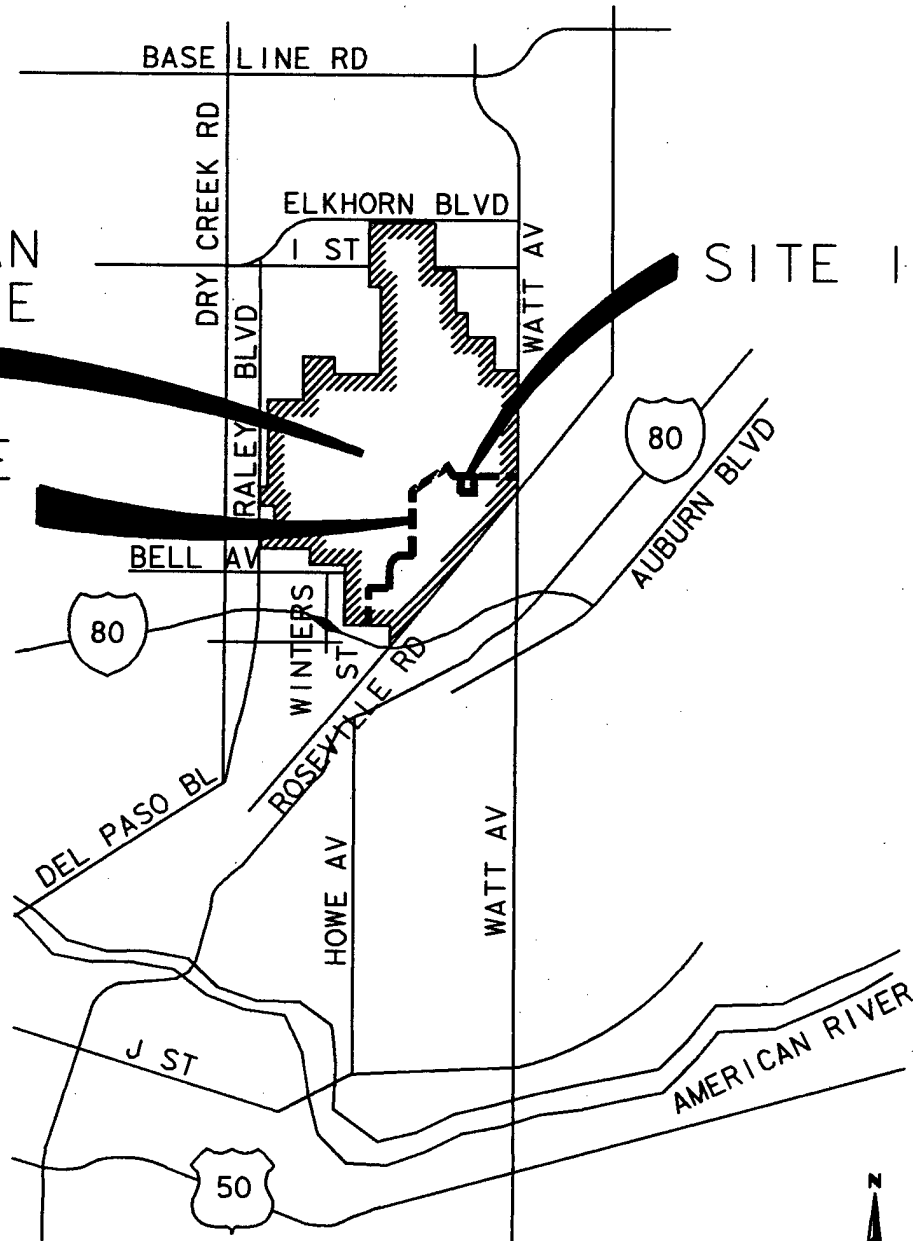
Groundwater samples were collected by the McClellan AFB field team from the DPE system and the ultraviolet/oxidation (UV/Ox) stream at the GWTP and shipped to EPS for analysis of contaminant concentrations. The groundwater sample analytical results (Appendix D) showed that a wider variety of compounds was present in the sample collected from the DPE system site. It was determined that the higher contaminant concentrations and the larger number of contaminants provided a better basis to demonstrate the EC system performance.

Site IC 29 is an approximately nine-acre area in the north-central portion of OU A. Site IC 29 is divided into three potential release locations and three study areas. Past site operations included an industrial waste line (IWL), plating shop, sandblasting shop, lacquer shop, chemical degreasing operations, hydraulic pump and motor repair shop, solvent spray booths, underground storage tanks (USTs), sumps, and a physical testing laboratory. These activities have resulted in soil and groundwater contamination. Contaminants include VOCs, semivolatile organic compounds (SVOCs), fuel hydrocarbons, and various metals. Site IC 31, which is adjacent to Site 29, is the physical location of the DPE treatment system which is located adjacent to the concrete pad with a catalytic oxidation unit treating vapors from two soil vapor extraction (SVE) systems.

McCLELLAN
AIR FORCE
BASE

OPERABLE
UNIT A

SITE IC 29



SCALE IN MILES

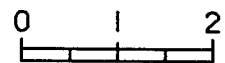


FIGURE 2-1

SITE IC 29 OU A
SITE LOCATION MAP
McCLELLAN AFB
SACRAMENTO, CA

2.2 GEOLOGY

From the surface to a depth of 450 feet below ground surface (bgs), the subsurface at McClellan AFB consists of alluvial and fluvial sediments eroded from the Sierra Nevada mountains and deposited over the last 5 million years. Soils found in the vadose zone are composed of interbedded layers of sands, silts, and clays. The thickness of most layers varies from a few inches to 5 feet, particularly in the upper 40 feet of the vadose zone. In some parts of McClellan AFB, layers may be 6- to 35-feet thick at depths greater than 40 feet bgs. A silica-cemented hardpan, approximately 2- to 4-inches thick, has developed over large areas of the base at 3 to 10 feet bgs. This hardpan may impede, but does not halt the downward percolation of surface water that infiltrates the subsurface soil (McClellan AFB 1996). The lithology, based on borings in the northern portion of Site IC 29, is predominantly sand, silty sand, and silt. The depth of VOC contamination in the vadose zone, as demonstrated by downhole soil gas measurements, is from 20 to 100 feet bgs.

2.3 HYDROGEOLOGY

Groundwater beneath McClellan AFB is present in both confined and unconfined conditions and has been tapped for municipal, domestic, and agricultural purposes for many years. Currently, the depth to groundwater is approximately 100 to 110 feet bgs. Flow directions in the hydraulic system have varied over the past 180 years, but have persisted in a south to southwesterly direction over the past decade. The subsurface beneath McClellan AFB has been divided into the vadose zone and five monitoring zones (A, B, C, D, and E, from shallowest to deepest) on the basis of lithologic, geologic and hydrologic characteristics. The vertical hydraulic gradient between monitoring zones A and B is predominantly downward, except in areas where shallow extraction occurs. The horizontal hydraulic conductivity of layered sediments is about 5 to 15 times the vertical hydraulic conductivity (McClellan AFB 1996).

Basewide data collected during remedial investigations and groundwater sampling efforts indicate that groundwater from 100 to 425 feet bgs beneath McClellan AFB is one hydraulic system (McClellan AFB 1996). Fine-grained deposits used to define the monitoring zones are not continuous and allow groundwater movement and contaminant migration between monitoring zones. The A monitoring zone is unconfined; deeper monitoring zones show characteristics of leaky confined aquifers with hydraulic communication between monitoring zones. The water elevation within the aquifer system has been declining for approximately 50 years due to overdrafting. Within the last 10 years, water levels in the A monitoring zone have been declining at a rate of 1.25 to 2 feet per year (McClellan AFB 1996). Groundwater elevations rise and fall by an average of five feet due to seasonal fluctuations (McClellan AFB 1996).

2.4 CONTAMINANT DISTRIBUTION

Groundwater beneath Site IC 29 is contaminated with 1,1-DCE, cis-1,2-DCE, TCE, benzene, carbon tetrachloride, and chloroform exceeding maximum contaminant levels (MCLs). The former washrack and USTs most likely were the primary sources of the groundwater contamination in the northern and western part of Site IC 29. Furthermore, a screening health risk assessment for Site IC 29 indicates that this contaminant mass presents an unacceptable carcinogenic risk of 0.0028 and a hazard index of 9 (Jacobs 1995). These findings caused McClellan AFB to begin an SVE removal action to prevent the additional release of contaminants to groundwater.

One sample was collected by McClellan AFB personnel at the inlet to the Site IC 29 treatment system during the first quarter of 1998. The sample was shipped to EPS' laboratory in Baltimore, Maryland and

- 1 analyzed for target contaminants by Method U.S. Environmental Protection Agency (EPA) 8260B. The
2 contaminants of concern measured in the groundwater from Site IC 29 are presented in Table 2-1.

Table 2-1
CONTAMINANTS OF CONCERN

Compound name	Concentration ($\mu\text{g/L}$)	Maximum Contaminant Levels ($\mu\text{g/L}$)
Benzene	9	1
Carbon tetrachloride	250	0.5
Chloroform	93	100
1,1-Dichloroethene	110	6
cis-1,2-Dichloroethene	82	5
Trichloroethene	4,700	5

$\mu\text{g/L}$ Micrograms per liter

2.5 DUAL-PHASE EXTRACTION SYSTEM DESCRIPTION

The DPE system consists of skid-mounted high-vacuum, dual-phase extraction (HVDPE) equipment, a combined low-vacuum, dual-phase extraction (LVDPE) and vapor treatment skid, a liquid treatment (air stripper) skid, equalization and effluent tanks, and auxiliary transfer pumps. Contaminated groundwater (from Site IC 29) is extracted from the extraction wells using submersible electric and pneumatic groundwater pumps. The groundwater, conveyed to the DPE treatment pad, is treated with an air stripper to remove VOCs and then discharged to the base IWL. As a result of base closure, the IWL will eventually be decommissioned. At that time, the pretreated groundwater from the DPE system will be placed in the east-west treated, groundwater conveyance line that will connect the groundwater extraction systems located on the east side of McClellan AFB to the GWTP. Effluent vapors from the air stripper are conveyed to the adjacent Site IC 31 SVE/catalytic oxidation system where they are treated (with either thermal oxidation or vapor-phase GAC) before being released to the atmosphere. Extraction of contaminated vapors (from the extraction wells) occurs simultaneously with groundwater extraction, using a combination of high-vacuum liquid-ring pumps and a low-vacuum blower.

Table 2-2 presents groundwater sampling analytical results from November and December 1997 and January and February 1998 (Radian 1997, 1998)

Table 2-2

**GROUNDWATER CONTAMINANT CONCENTRATIONS AT THE
DUAL-PHASE EXTRACTION SYSTEM**

Compound Name	Concentration ($\mu\text{g/L}$)				Maximum Contaminant Levels ($\mu\text{g/L}$)
	11/97	12/97	1/98	2/98	
Sample Date	11/97	12/97	1/98	2/98	
Benzene	NR	NR	NR	NR	1
Carbon tetrachloride	270	92	320	390	0.5
Chloroform	98	230	130	180	100
1,1-Dichloroethene	110	100	130	150	6
cis-1,2-Dichloroethene	67	66	120	120	5
Trichloroethene	4,000	4,000	6,600	8,400	5

NR Not reported
 $\mu\text{g/L}$ Micrograms per liter

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3.0 TECHNOLOGY DESCRIPTION

3.1 PRINCIPLE OF TECHNOLOGY

The EC process is an advanced oxidation process (AOP) that uses ozone to oxidize pollutants in water. A high grade of activated carbon is used as the catalyst. As the water and ozone come in contact with the catalyst, both ozone and contaminants adsorb onto the catalyst surface. The ozone molecule decomposes into atomic oxygen radicals (O^-) which react with the adsorbed contaminants. The reaction products then desorb from the catalyst surface. Because the oxidation reaction is localized on the catalyst surface and does not involve hydroxyl radicals (OH^-), the reaction is not affected by the presence of radical scavengers in the bulk liquid phase.

Since the reaction proceeds via the O^- operation, low (even negative) pH levels are possible. The reaction proceeds unhindered over a broad temperature range (from 4 degrees centigrade [$^{\circ}C$] up to $80^{\circ}C$). Complete mineralization to water (H_2O), carbon dioxide (CO_2), and inorganic ions can occur. Most organic compounds can be oxidized (Kaptijn 1997).

Catalytic ozonation involves the oxidation of dissolved organic compounds using ozone in a fixed-bed reactor filled with a catalyst. The catalyst, called C1000, is a proprietary formulation of high grade activated carbon, free of metals and other substances. The process itself produces no residuals that require further treatment or specialized handling. Operating across a broad temperature and pH spectrum, it has shown to be effective at relatively complete removal of most organics. The elimination of the need for ultraviolet (UV) lights and additional chemicals (e.g., hydrogen peroxide), coupled with a mechanism that maximizes the effectiveness of ozone and significantly reduces scavenger activity, results in lower operating costs than straight ozonation and other AOPs.

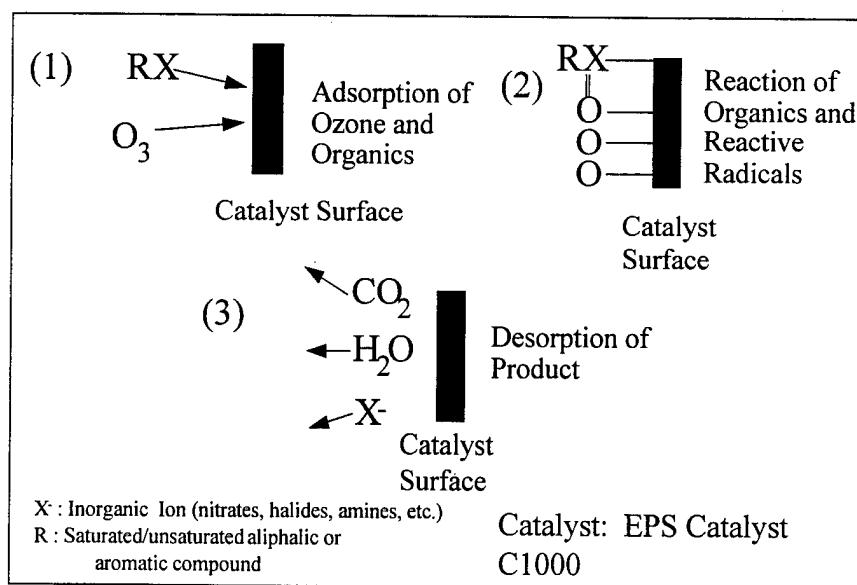
The EC catalytic ozonation process comprises several steps: transport of both ozone and organics (from the liquid phase) to the catalyst surface, adsorption of the organics and ozone on the catalyst surface, decomposition of ozone into three atomic oxygen radicals, reaction between adsorbed organics and the O^- radicals on the catalyst surface, and desorption of the reaction products from the catalyst surface. Figure 3-1 illustrates the EC process mechanism.

Activated carbon is well known as an excellent adsorbent for organic molecules. When properly applied, molecular oxygen (O_2) can form atomic O^- at the surface of carbon. However, as oxygen is a very stable component, the formation of these radicals will only take place at elevated temperatures (greater than $400^{\circ}C$). Ozone (O_3), being a much less stable form of oxygen, can be converted into radicals at ambient temperatures. The radicals formed in the catalytic ozonation process are assumed to be the same as the known surface radicals from oxygen, namely O^- , O_2^- and O_3^- . It has been demonstrated that the surface reaction does not involve OH^- . This mechanism affords greater oxidative power in that three O^- radicals are generated from each ozone molecule versus the one OH^- radical that is generated in straight ozone and traditional AOP systems. The combined oxidative potential of three O^- radicals is 7.26 volts compared to 2.80 volts for one OH^- radical.

Furthermore, since the reaction is taking place on the surface of the catalyst where the target organics are adsorbed, the effects of scavenger traps that are found in the other aqueous-phase systems are significantly reduced. These scavenger traps consume the oxidation radicals without contributing to organic (chemical oxygen demand [COD], color, toxicity, etc.) reduction.

Figure 3-1

PROCESS MECHANISM



3.2 WASTE AND MEDIA APPLICABILITY

The EC technology is designed to treat organic contaminants in process water, wastewater, or extracted groundwater. It is not applicable to other media, such as air or soil.

Laboratory, pilot-scale, and full-scale work has revealed that nearly all organic compounds can be cost-effectively oxidized by EC, including the chlorinated aliphatics TCE, cis-1,2-DCE, PCE, 1,2-DCA; short-chain organic acids; sulphonates; most (poly) aromatics, including those which are halogenated; saturated and unsaturated hydrocarbons, including those which are halogenated; amines, if adsorbable; alcohols and carboxylic acids, if adsorbable (usually at lower pHs); and inorganic compounds dependent on the contaminant matrix (Kaptijn, et al. 1994; Kaptijn 1997).

Any contaminant mixtures consisting of the components noted above have the potential to be remediated. EC has demonstrated its effectiveness at remediating groundwater and industrial wastewaters. Cost effectiveness is relative based on the circumstances and treatment alternatives available at the time (Kaptijn, et al. 1997; Kaptijn 1997).

The EC technology is not applicable to waste streams containing contaminants which (1) are not adsorbable on the surface of the catalyst, and (2) which are not capable of being treated by oxidation. Examples of these contaminants include:

- Metals
- Waste streams containing oily, or other non-aqueous phase liquids (NAPL)
- Mixed (radioactive) wastes

Furthermore, as previously-identified, some organic constituents, e.g., carbon tetrachloride, cannot cost-effectively be treated with EC due to either the long residence time, or high ozone dose (or both) required to achieve the desired effluent concentration.

3.3 ADVANTAGES AND DISADVANTAGES

The advantages of the EC technology are:

- Three times the oxidation potential over AOPs utilizing hydrogen peroxide since three O⁻ are formed from each O₃ molecule compared to one OH⁻ formed from each hydrogen peroxide molecule.
- Relatively (compared to other AOPs) unaffected by radical scavengers.
- Operable over a wide range of temperatures (4 deg C to 80 deg C).
- Operable at low pH.
- Lower operating cost than straight ozonation (since the increased effectiveness of the EC process allows the addition of less excess ozone than required for straight ozonation), and other AOPs (since no energy-intensive UV lamps are required).

The limitations of the EC technology are:

- Requires pre-filtering of the influent if either iron or manganese concentrations exceed 1.0 ppm.
- Requires pre-filtering of the influent if particulates larger than 20 microns are present in the influent stream.
- Cannot be used to treat NAPLs or emulsions.
- Cannot be used to treat metals or other contaminants that cannot be adsorbed onto the catalyst.
- No cost-effective for final treatment of influent streams with chemical oxygen demand (COD) exceeding 50,000 ppmb (though it can be used as a primary treatment process to reduce COD from 50,000 ppmv to less than 5,000 ppmv).
- May not be cost-effective for treatment some compounds (e.g., CTCL) due to either the long residence time required, or high ozone dose required, or both.

3.4 DEVELOPMENT STATUS

EPS has five years of experience in the application of the EC technology for industrial wastewater treatment and recycling and five years of experience in the application of EC technology for landfill leachate treatment. The technology has been effectively used for organic destruction in aqueous streams. Specific project experience includes: Stork Industries, groundwater treatment system, Nijkirk, Netherlands; Hamberg Landfill, leachate treatment system, Hamberg, Germany; Berg Landfill, leachate treatment system, Berg, Germany; BASF, nitromatic treatment system, Schwarzhede, Germany.

A full-scale EC operation in the Netherlands treats 88 gallons per minute of groundwater to remove TCA (reducing concentrations from 400 parts per billion [ppb] to 5 ppb), TCE (reducing concentrations from 180 ppb to less than 1 ppb), and benzene, toluene, ethylbenzene, and total xylene isomers (BTEX) (reducing concentrations from 50 ppb to less than 0.2 ppb). This facility has been in successful operation since 1992.

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4.0 OBJECTIVES

This section describes the objectives and test plan for the EC demonstration. It includes the expected types of data analyses to facilitate demonstration results interpretation.

4.1 GENERAL OVERVIEW

The purpose of this demonstration is to collect reliable field data on the performance, operability, and cost-effectiveness of EC technology for the treatment of extracted, contaminated McClellan AFB groundwater. To accomplish this task, a pilot testing program will be conducted to evaluate the effectiveness of the technology to treat McClellan AFB groundwater contaminated with chlorinated solvents. The demonstration project will provide the quality data required to assess the capital and operation and maintenance (O&M) costs and performance of this technology at the pilot and full-scale levels.

4.2 DESCRIPTION OF TECHNOLOGY PROCESS

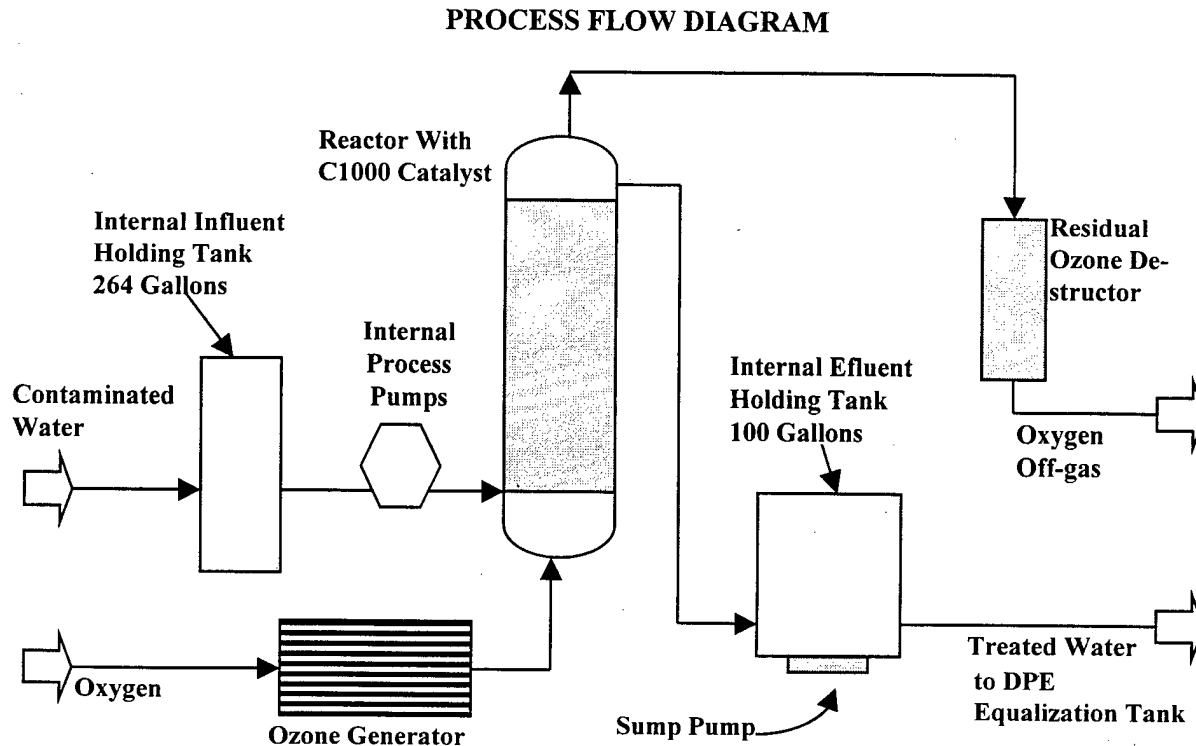
EC is based on catalytic oxidation of pollutants in a fixed-bed reactor. Ozone and contaminated water are fed (concurrent, up flow) to the reactor and the oxidation reaction takes place on the catalyst surface. The catalyst is a special grade of activated carbon that is free of metals or any other active ingredients. While the catalyst does exhibit adsorptive qualities, its purpose is to provide a surface for the oxidation reaction to take place. As such it does not become loaded as in traditional activated carbon applications and therefore does not require frequent replacement. Currently, the performance guarantee for the catalyst is three years.

In many cases, one reactor is suitable. For high conversions or for discharge requirements at the ppb level or below, multiple reactors may be placed in series. Residence times and ozone dosage depend mainly on the concentration and nature of the components to be oxidized.

The primary components of the system are the EC reactor(s), an ozone generator and residual ozone destructor. Ozone and contaminated water (groundwater, wastewater, or process water) are fed to the reactors in the same direction from the bottom to the top of the reactor. Additionally the system also includes a 264-gallon influent equalization tank, process feed pumps, effluent holding tank, and sump pump. Since the half-life of ozone in water is relatively short (less than 5 minutes), no water-phase residual ozone destruction unit is required. Figure 4-1 illustrates a process flow diagram.

During the demonstration, the EC system will be receiving influent from the combined Site IC groundwater wells and will return the treated effluent to the DPE unit equalization tank.

Figure 4-1



4.3 STATEMENT OF DEMONSTRATION'S OBJECTIVES

Based on the project work statement (PWS), there are four objectives for this proposed project:

- Demonstrate the ability of the ozone system to obtain removal efficiencies and removal rates for (a) total organics, and (b) chlorinated organic compounds as functions of inlet concentration, catalyst bed hydraulic residence time, and ozone concentration.
- Demonstrate the real-world operating characteristics of a catalyzed ozone treatment system for groundwater pump-and-treat applications.
- Quantify the cost and performance data for the catalyzed ozone treatment system under field conditions encountered at McClellan AFB, comparing the capital and operating costs to those of conventional treatment technologies.
- Verify that the treated effluent from the system meets applicable regulatory requirements for discharge to publicly owned treatment works and surface waters.

To demonstrate chemical degradation, the removal efficiencies (reported as a percent removal) and removal rates (calculated as the mass of organics and chlorinated compounds removed per day) will be determined from the analytical results of paired grab samples collected from the system inlet and effluent streams. The mass removed is determined from the difference in the mass fed (flow rate times concentration) and the mass exiting the system in the effluent. The reactor residence time is calculated by dividing the feed flow rate by the volume of the reactor. The feed flow rate is one of the parameters that will be logged on a routine basis.

Operator attention requirements will be determined directly from an operator's log, maintained by the pilot system operator. The parameters for system operation will be determined by comparing demonstration data at different residence times.

4.4 TEST PLAN

The test plan is based on a 5-month (22-week) laboratory-scale and field pilot demonstration. The specific tasks are outlined below:

- Task 1 Perform preoperation sampling and laboratory-scale testing (6 weeks)
- Task 2 Installation and start-up (1 week)
- Task 3 System optimization (6 weeks)
- Task 4 Continuous operations and testing (8 weeks)
- Task 5 Demobilization (1 week)

Task 1. The first task will be to perform a laboratory-scale trial to determine the optimal ozone dose (based on observed influent concentrations to the DPE, 1,000 ppm will be used as the initial ozone dose; this dose will be revised based on the outcome of the laboratory-scale trial) and determine an appropriate hydraulic residence time that will be used during the optimization phase of the demonstration. For the laboratory scale test, 120 gallons (450 liters) of water will be needed. The water will be collected from Site IC 29 and shipped in four, 30-gallon plastic drums to EPS' laboratory in Baltimore, Maryland. The drums will be filled completely to provide as little head space as possible to minimize volatilization, and shipped by truck freight.

Laboratory-scale testing, in which residence time and ozone doses are varied, is used to optimize the EC system performance. The performed tests provide information regarding removal of the target compounds with corresponding liquid residence time and ozone consumption. These results will be used to determine the feasibility of system implementation.

The basic procedure in the EC laboratory-scale trial is as follows:

- Adsorption isotherms of the target compound for the EC catalyst are developed and used to select loading requirements.
- The test column catalyst is loaded with organic material.
- Liquid flow rate, ozone concentration, and gas flow rate are adjusted to the desired settings.
- The reactor is operated until steady state effluent condition are reached.

Table 4-1 presents the reactor test setup parameters.

Table 4-1

LABORATORY-SCALE TESTING PARAMETERS

Parameter	Dimension
Catalyst mass	≈40 grams
Diameter	22 millimeters (mm)
Bed length	300 mm
Empty-bed volume	123.5 milliliters (ml)
Liquid flow	variable depending on desired residence time
Gas flow	≈80 to 100 ml/minute
Ozone feed gas concentration	variable depending on ozone dose

≈ Approximately

It should be noted the results obtained during the laboratory-scale testing program are based on a single grab-sample, and will be used only to determine initial field optimization conditions.

EPS will follow a standard procedure for the laboratory-scale trial. This trial consists of the following specific steps:

Step 1: Perform a baseline analysis of the influent groundwater sample.

Step 2: Develop an isotherm to understand the adsorptive behavior of the target components. This information allows EPS to determine the approximate time required to fully saturate a given amount of catalyst. Specific analysis of samples is required to confirm saturation levels. The following steps are employed in developing an isotherm:

- Place 0.5 liters of water in each of six flasks
- Add catalyst to each flask according to the following schedule*

Flask One - 0.1 gram
Flask Two - 0.2 gram
Flask Three - 0.5 gram
Flask Four - 1.0 gram
Flask Five - 2.0 grams
Flask Six - 4.0 grams

*These are estimates only as the exact amount will be a function of the concentration of target organics in the groundwater.

- Shake flasks for 48 hours to establish equilibrium between the catalyst and adsorbing components.

- 1 - Draw sample of the water from each flask.
- 2 - Filter sample and analyze the water for VOCs via EPA Method 8260B.
- 3 - Develop graphical isotherms based on results and interpret.

4 **Step 3:** Load the catalyst to develop a saturation profile. This is achieved by processing groundwater
5 through the reactor WITHOUT ozone addition. The catalyst will therefore become saturated over time.
6 To demonstrate that oxidation is the mechanism that is removing the organics, the groundwater is passed
7 through the catalyst without ozone to cause breakthrough of the GAC and allow the effluent concentra-
8 tion of organics to exceed the target discharge concentrations, but not reach the influent concentration.
9 For this demonstration project, target discharge concentrations will be defined as the IWTP's discharge
10 permit limits. Once this effluent concentration has been achieved, ozone is applied. As oxidation occurs
11 the effluent concentration will decrease and be controlled by the ozone doses and residence times that are
12 applied.

13 **Step 4:** Apply ozone and adjust groundwater flow rate to attain Condition One requirements (Section 7,
14 Table 7-1 for estimated condition requirements) until equilibrium is achieved.

15 **Step 5:** Obtain samples and analyze.

16 **Step 6:** Apply ozone and control groundwater flow rate to attain Condition Two requirements (Section 7,
17 Table 7-1; some adjustment based on analytical results may be required) until equilibrium (steady state) is
18 achieved.

19 **Step 7:** Obtain samples and analyze.

20 **Step 8:** Apply ozone and adjust groundwater flow rate to attain Condition Three requirements (Section
21 7, Table 7-1; some adjustment based on analytical results may be required) until equilibrium is achieved.

22 **Step 9:** Obtain samples and analyze.

23 **Step 10:** Apply ozone and adjust groundwater flow rate to attain Condition Four requirements (Section
24 7, Table 7-1; some adjustment based on analytical results may be required) until equilibrium is achieved.

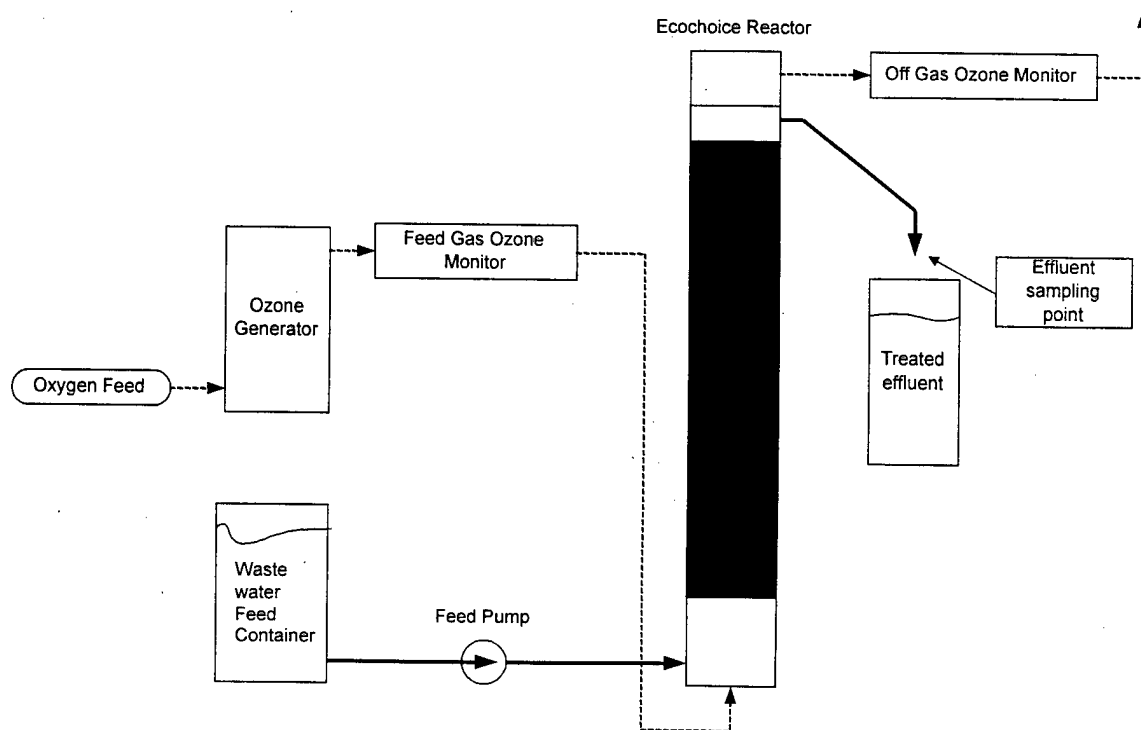
25 **Step 11:** Obtain samples and analyze.

26 **Step 12:** Evaluate all results.

27 EC will conduct laboratory-scale tests in glass column reactors that contain the catalyst bed. Figure 4-2
28 shows a simplified flow diagram for the configuration. The groundwater is fed up-flow through the
29 catalyst bed from a sample container. Ozone gas is also fed up-flow through the catalyst bed. The efflu-
30 ent from the catalyst bed is collected in a second sample container. The feed and effluent ozone concen-
31 trations are monitored continuously.

Figure 4-2

LABORATORY-SCALE TEST SETUP



Task 2. EC's pilot-scale system will be mobilized and shipped to the DPE treatment system at McClellan AFB. The EC system trailer will then be positioned at the site and set up for operation. All utility connections will be made and the system will be connected as a slipstream upstream of the DPE system equalization tank. Figure 4-3 depicts the proposed pilot-scale treatment system layout.

After installation, the system will be checked for proper mechanical operation. In addition, a liquid oxygen (LO_x) container will be connected to the ozone generator system and the ozone generator function will be checked. All measurement instruments will be calibrated to ensure precision, accuracy, and repeatability within the data quality objective (DQO) requirements and URSG/EPS will verify that the system is ready for optimization.

Process startup will occur by first filling a 264-gallon flow equalization tank (located in EC's system trailer) which will be used to maintain a steady flow of contaminated water to the system. This tank is equipped with high- and low-level controls to maintain the water level in the tank and allow for continuous flow to the system should there be a temporary stop in source water. There will be no sample collection during startup activities.

Task 3. The third step will be to perform an on-site, pilot-scale trial to determine ozone application parameters, reactor vessel requirements, and other optimization parameters. Pilot-scale testing will be divided into two periods: optimization and operation (Task 4). During the optimization period, the ozone addition, reactor vessel parameters, and flow rate will be adjusted to determine the optimal performance of the system. Detailed layout of the steps to be followed in this task can be found in Section 5.0 Field Activities.

1 **Task 4.** Once the system has been optimized, it will be operated to demonstrate performance and com-
2 pliance with applicable regulatory requirements. Sampling of the system off-gas will also be conducted
3 to quantify the system air emissions. Detailed layout of the steps to be followed in this task can be found
4 in Section 5.0, Field Activities.

5 **Task 5.** After the demonstration is complete, the system will be demobilized. Before demobilization, all
6 measurement devices as well as field analyzers will be calibrated to ensure precision, accuracy, and re-
7 peatability within the DQO requirements and to determine to what extent, if any, drift occurred in the
8 measurement process. After the trailer is transported off-site, general housekeeping and clean up of the
9 site will be conducted to restore it to its appropriate pre-demonstration condition. The McClellan AFB
10 field team will inspect the site following demobilization, and verify the site has been restored to the satis-
11 faction of the government.

12 **4.5 TECHNOLOGY PARAMETERS EVALUATION**

13 The performance evaluation parameters which demonstrate the capabilities of the EC system are the per-
14 cent removal of organic and chlorinated organic compounds detected and the removal rates of each com-
15 pound detected. The performance evaluation parameters, which demonstrate real-world operating pa-
16 rameters are the variations in feed concentrations, the system operating up time, ozone usage rate,
17 electricity usage rate, and the operator log sheet recordings. The performance evaluation parameters that
18 will be used for design criteria for a full-scale EC system are the target compound loading rates, the re-
19 actor residence time, ozone dose, and the required effluent quality.

20 The performance evaluation parameters that will be used to quantify capital and operating costs are the
21 process capacity of the system, power consumption, and the oxygen/ozone usage requirements. Capital
22 and operating costs for conventional treatment will be determined using existing data available from
23 McClellan AFB quarterly operating reports. The sizing of conventional systems will be based on current
24 McClellan AFB systems and data from sources not included as part of the demonstration.

25 The chemical operating parameters include oxygen demand, ozone consumption, and the concentration of
26 target and matrix compounds in the feed stream. The physical operating parameters include gas flow rate
27 and reactor residence time.

28 **4.6 DATA ANALYSIS AND INTERPRETATION**

29 The sample and analysis plan provides for the collection of data that will be used to determine destruction
30 efficiency in terms of absolute effluent values (i.e., ppm) and percentages. Destruction efficiency in per-
31 cent will be calculated using the following equation: $(\text{influent concentration} - \text{effluent concentra-}$
32 $\text{tion}) / \text{influent concentration} * 100$. The data will be collected in such a manner that each set of data con-
33 tains paired influent and effluent values. Further multiple sets (four in the lab phase, three in the field
34 phase) will be collected at the same time to establish statistical validity and significance. System effluent
35 samples will be collected over the duration of the demonstration, and these samples will be grouped ac-
36 cording to the experimental operating conditions at the time of their collection.

37 At the completion of the demonstration project, statistical evaluation of the analytical data will be con-
38 ducted. The data will first be tested using a Lillefor's test to determine whether the data set is normally
39 distributed. If so, the data will be analyzed using parametric statistics to determine the first, second, and
40 third order standard deviations of the data sets. If the data is determined to be non-normally distributed, a
41 number of transformations will be applied to the data set to determine if it can be normalized. Should

1 these transformations fail to provide a normal distribution, non-parametric statistics will be used to de-
2 termine the first, second, and third order standard deviations of the data sets. It is likely the data set will
3 not be normally distributed since the groundwater at Site IC 29 is contaminated with NAPLs that may
4 cause a wide variation in contaminant concentrations (measured at the influent to the EC system). There-
5 fore it is anticipated that the statistical analysis will be performed on the difference between the contami-
6 nant mass flow rates measured as the influent and effluent of the EC reactor vessels. It is anticipated that
7 the data generated by the difference between the influent and effluent will be amenable to analysis by a
8 one-sided test. However, until the data has been generated, the actual method of analysis is not definite.

9 The influent and effluent data will then be plotted versus time and operating conditions. These plots will
10 graphically show how any gradual changes in the data over the course of the demonstration. The organic
11 concentrations, other analytical results, flows, and operating log sheets will be used to calculate mass of
12 contaminants to and from the system, as well as accumulation and destruction within the system.

13 The final step will be to utilize the process and cost data obtained during the pilot-scale testing, determine
14 optimal operating parameters (ozone/oxygen feed rates, power, flow rates, etc.), determine scale-up fac-
15 tors and equipment sizing for different treatment feed rates, and pricing (capital and operating costs) for
16 full-scale application at McClellan AFB sites. These costs will be compared to those associated with
17 conventional technologies. DQOs for the demonstration are discussed in Section 8.0.

5.0 FIELD ACTIVITIES

This section describes the field activities that will be performed at the pilot test site to fulfill the project objectives presented in Section 4. Activities are presented in six subsections:

- Preoperation Characterization. Characterization activities to be performed before installing and operating the EC system.
- System Installation. The installation of the EC reactor system
- System Operation. Operational procedures for the EC reactors during each operational phase.
- Material Storage. Management of materials to be used during the demonstration.
- Residuals Management. Management and disposal methods for waste residuals generated during the demonstration.
- Demobilization and Site Restoration. The procedures for leaving the site in an acceptable condition after completing the demonstration.

It should be noted that the following discussion is general in nature. The configuration of the system will be determined after the completion of the laboratory-scale testing. Once complete, an addendum to this work implementation plan (WIP) will be developed and submitted to McClellan AFB for review and approval. Upon approval, the addendum will become part of this WIP.

5.1 PREOPERATION CHARACTERIZATION

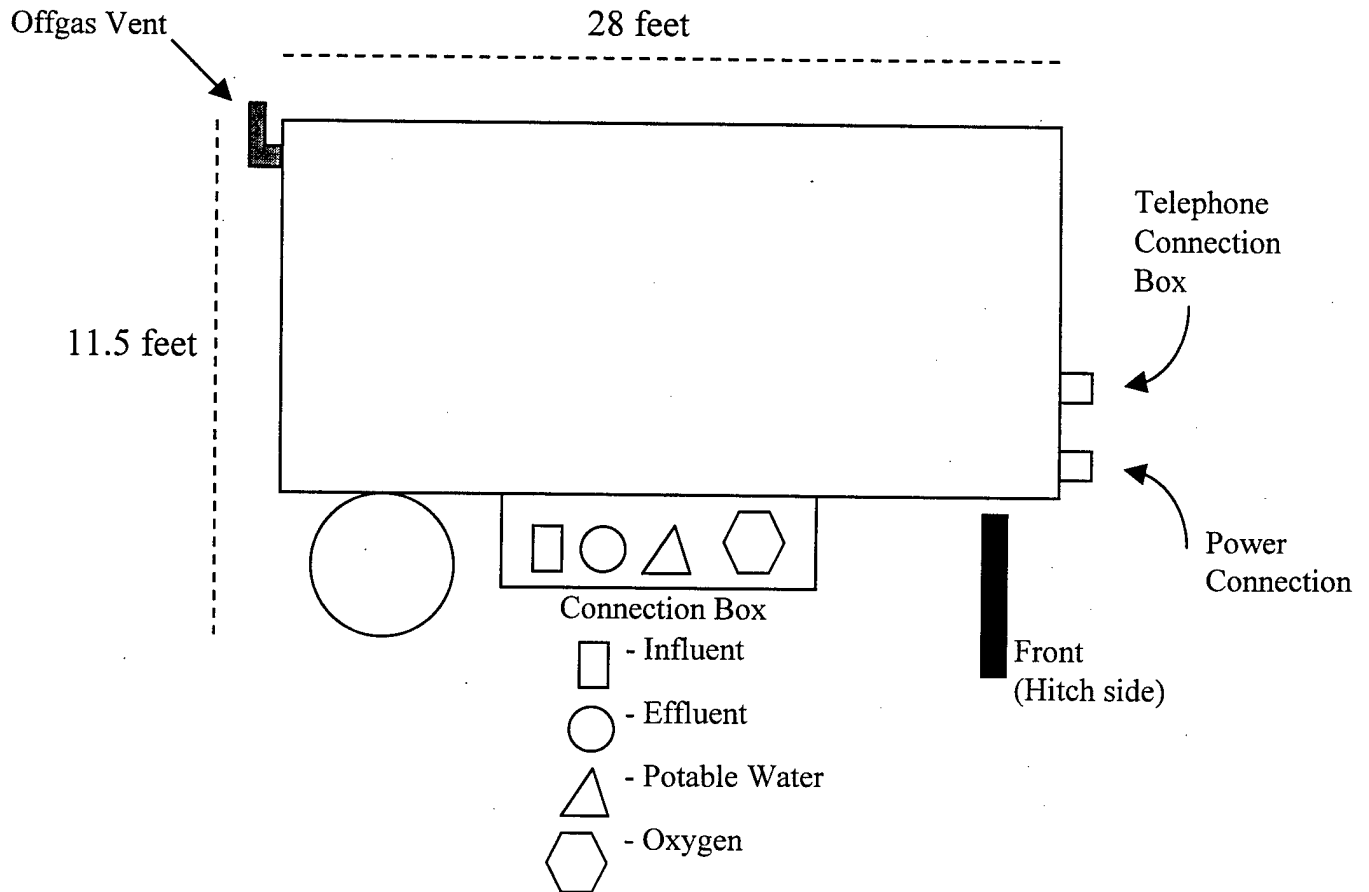
To facilitate preoperation characterization, URSG will collect and prepare for shipment 120 gallons of groundwater. The groundwater will be shipped in four 30-gallon drums to EPS' laboratory in Baltimore, Maryland where laboratory-scale testing will be performed. This testing is necessary to establish operational process parameters prior to initiating the pilot scale demonstration. Details of preoperation characterization are presented in Section 4 and Section 7.

5.2 SYSTEM INSTALLATION

The EPS pilot plant will be transported to Site IC 31, McClellan AFB. Process components of the demonstration system will include a 264-gallon equalization tank, two feed pumps (in parallel), reactor(s) with C1000 catalyst, ozone generator, vapor-phase residual ozone destructor, an effluent holding tank, discharge sump pump, and associated piping and controls. The entire process component assembly will be housed within a 28-foot-long, 8-foot-wide, and 11-1/2-foot-high trailer. Figure 5-1 shows a side view of the trailer. While the actual layout of the equipment within the pilot-scale test trailer will be determined based on the results of the laboratory-scale testing the equipment layout used at other pilot-scale tests can be seen in photographs included in Appendix C.

Figure 5-1

SIDE VIEW OF PILOT PLANT



The trailer will be placed on the existing concrete pad adjacent to Site IC 31, and unloaded from the tractor. The trailer wheels will be secured with chocks and the trailer leveled. URSG personnel will inspect the trailer and contents to ensure all process components are in place and operable. Utilities, as described below, will be connected to the trailer. A groundwater influent line will be run from the south side of the DPE treatment system to the trailer and a treated effluent line will be run back to the contaminated groundwater line that feeds into the DPE equalization tank. The position of these lines are depicted in Figure 4-3 of the previous section. Following utility connections, a preoperation check will be conducted to ensure system operability. All measurement devices as well as field analyzers will be calibrated to ensure precision, accuracy, and repeatability within the DQO requirements. Measurement devices and DQO requirements are listed in Table 5-1 and discussed in the quality assurance project plan (QAPP) in Section 8.

Table 5-1

**ANALYZER/MEASURING DEVICE AND MONITORING METHOD
DATA QUALITY OBJECTIVES**

Process Variable	Analyzer/Measuring Device	Monitoring Method	Data Quality Objective
Groundwater feed rate	Totalizer: Neptune T10, 1"; Bailey-Fisher & Porter # 10 rotameter	Manually record time, total, and flow rate	Cross-check totalizer with rotameter
Ozone feed rate	IN USA Type H1-X ozone meter; Bailey-Fisher & Porter # 10 rotameter	Manually record ozone concentration and flow rate	Instrument internal (see note)
Reactor ozone discharge rate	IN USA Type H1-L ozone meter, Bailey-Fisher & Porter # 10 rotameter	Manually record ozone concentration and flow rate	Instrument internal (see note)
System ozone discharge rate	IN USA Type H1-L ozone meter, Bailey-Fisher & Porter # 10 rotameter	Manually record ozone concentration and flow rate	Instrument internal (see note)
Ambient ozone in system enclosure	IN USA Type H1-L ozone meter	Manually record ozone concentration	Instrument internal (see note)
Electrical power consumption	Standard electrical meter	Manually record meter reading	None

Note: On start-up, the IN USA ozone analyzer runs an internal self-check. During self-check the instrument tests its internal electronics, UV lamp, photo sensor operation, and zero concentration. Instrument repeatability and accuracy specifications are contained in Attachment A.

Process/Utility Requirements

All utilities installed for the field pilot EC demonstration will be temporary. The anticipated utility requirements for the demonstration are listed below.

Influent Connection. The process inlet connection is a 1-inch diameter, Schedule 80, polyvinyl chloride (PVC), female pipe thread.

Effluent Connection. The process effluent connection is a 1-inch diameter, Schedule 80, PVC, female pipe thread.

Power. One 240-volt, single-phase, 100-amp power line, with an on-line meter. The pilot plant is equipped with a straight-blade, 3-pole, 4-wire, 50-amp, 125/250-volt, National Electrical Manufacturers Association (NEMA) 14-50R grounding plug for power source connection. (If needed, the pilot plant is also equipped with a 50-foot extension cable with a marine female receptacle for the pilot plant connection and a marine male plug with a male range plug adapter for connection to the power source.) The power supply should be surge-suppressed to prevent damage to the ozone generator's high voltage electronics due to power surges.

Water. Potable water is required for system support (sink, eyewash) and equipment cooling purposes. The connection for the potable water supply is a 3/4-inch female garden hose thread (GHT) connection.

Telephone Service. Two telephone lines will be required for this demonstration: one for a phone and another for a fax. The pilot unit is equipped to accept standard telephone connections.

Oxygen. Containerized liquid oxygen will be connected to the trailer using hardware provided by the vendor and EPS. Standard D45 containers will be used and will be secured in place outside the trailer, chained to a rack.

5.3 SYSTEM OPTIMIZATION AND OPERATION

The field demonstration will be conducted in two phases: system optimization and system operation. The anticipated duration of system optimization is a maximum of 6 weeks. The system operation will be conducted for a minimum of 8 weeks.

5.3.1 System Optimization

URSG personnel will operate the pilot plant to determine optimized process parameters. This will entail adjusting the ozone addition, reactor vessel parameters, and flow rate to determine the optimal system performance.

URSG personnel will collect 84 VOC samples (12 during catalyst loading followed by 3 sets of 4 samples per week for 6 weeks) from the system influent and treatment train to analyze the system performance and to enable understanding of the contaminant degradation pathways. Up to eight samples (four pairs) will be collected and analyzed for VOCs during the catalyst loading portion of the optimization phase. The reason for analyzing four pairs (influent and effluent of the reactor) is twofold:

- Verify and calibrate the catalyst isotherms developed during the laboratory-scale phase. This is required since the isotherms developed during the laboratory-scale phase will be based on the single grab sample collected for characterization purposes which may not be representative of the DPE influent stream.
- Determine the point when breakthrough of the catalyst has allowed effluent concentrations to exceed the target discharge concentrations, but no approach influent concentrations. This is because if influent concentrations are significantly greater than the target discharge concentrations, the length of time required to once again reduce effluent concentrations may be excessive (up to several weeks); this delay would prevent the completion of the pilot test within the desired schedule.

Additional samples will be collected for analysis of parameters including: iron, manganese, total suspended solids, total organic carbon, total inorganic carbon, and pH. Optimization operation parameters include ozone addition, reactor vessel parameters, and flow rate. Each operating parameter will be recorded at the time samples are collected. Appendix F presents a table of sample locations, frequencies, and analytical parameters for the optimization phase.

The sampling results will be used to make any modifications to the ozone addition, reactor vessel parameters, or flow rate required to optimize the system for the operation phase of the demonstration. Table 5-1 lists process variables and their monitoring methods for the demonstration.

Under URSG's direction, EPS will follow a standard procedure for the optimization phase of the field demonstration. This phase will consist of the following specific steps. See Section 7, Table 7-2 for estimated condition requirements; some adjustment based on analytical results may be required.

Step 1: Load the catalyst to develop a saturation profile. This is achieved by processing groundwater through the pilot scale reactor WITHOUT ozone addition. The catalyst will therefore become saturated over time. To demonstrate that oxidation is the mechanism that is removing the organics, the groundwater is passed through the catalyst without ozone to cause breakthrough of the GAC and allow the effluent concentration of organics to exceed target discharge but not reach influent concentrations. Once this effluent concentration has been achieved, ozone is applied. As oxidation occurs, the effluent concentration will decrease and be controlled by the ozone doses and residence times that are applied.

Step 2: Apply ozone and adjust groundwater flow rate to attain Condition One requirements until equilibrium is achieved.

Step 3: Obtain samples and analyze.

Step 4: Apply ozone and adjust groundwater flow rate to attain Condition Two requirements until equilibrium is achieved.

Step 5: Obtain samples and analyze.

Step 6: Apply ozone and adjust groundwater flow rate to attain Condition Three requirements until equilibrium is achieved.

Step 7: Obtain samples and analyze.

Step 8: Apply ozone and adjust groundwater flow rate to attain Condition Four requirements until equilibrium is achieved.

Step 9: Obtain samples and analyze.

Step 10: Apply ozone and adjust groundwater flow rate to attain Condition Five requirements until equilibrium is achieved.

Step 11: Obtain samples and analyze.

Step 12: Apply ozone and adjust groundwater flow rate to attain Condition Six requirements until equilibrium is achieved.

Step 13: Obtain samples and analyze.

Step 14: Evaluate results.

5.3.2 System Operation

System operation consists of all services required to document the system performance at McClellan AFB for the purpose of reporting the results to Department of Defense (DoD), and the regulatory and scientific community. System operational data will be collected according to the parameters and monitoring methods listed in Table 5.1. URSG personnel will operate the pilot plant under the optimized conditions that are determined during the previous phase. This will entail operational control and monitoring as well as sample collection and analysis.

URSG personnel will collect 48 VOC samples (not including 8 off-gas samples) from the treatment train during the demonstration phase. Process data, including system feed rate, ozone feed rate, total gallons

discharged, and electrical use will be collected at the time of each water sample collection. Sample collection methods, sampling locations, analytical methods, and data management are discussed in Section 7. Appendix G presents a table of sample locations, frequencies, and analytical parameters for the operation phase.

Under URSG's directions, EPS will follow a standard procedure for the operation phase. This phase will consist of the following specific steps.

Step 1: Apply ozone and adjust groundwater flow rate according to the optimum condition requirements determined during the optimization phase.

Step 2: Obtain samples and analyze at one-week intervals for eight weeks to demonstrate reproducibility of results and adaptability to groundwater concentration fluctuations.

5.4 MATERIAL STORAGE

Liquid oxygen will remain in the supplier's containers, secured to the exterior of the pilot plant, until use. During system operation, two standard D45 containers (arranged for gas-phase withdrawal) will be maintained, one that is in use and one backup. Suitable hose will be utilized to convey the gas-phase oxygen to the ozone generator. The manufacturer's procedures for handling and changing the D45 cylinder will be followed.

5.5 RESIDUALS MANAGEMENT

Representative samples of each type of residual waste will be collected and analyzed as appropriate for disposal (see Section 6). URSG will ensure that all wastes and residuals are handled properly. Wastes and residuals that will be generated include:

- Wastewater from sampling activities.
- Influent and effluent PVC piping and appurtenances from demobilization.
- Personal protective equipment (PPE) (e.g., latex gloves) from sampling.
- Solid waste from site activities.
- Waste from iron/manganese HACH® test kits.
- Aqueous waste from decontamination activities (Alconox® solution).

Effluent water will be discharged into the DPE equalization tank. It is anticipated that the effluent VOC concentrations will be below specified surface discharge limits, for all constituents of concern (except carbon tetrachloride). VOC concentrations water generated from sample collection activities will be poured into the pilot-test effluent holding tank which will then be pumped into the DPE equalization tank for treatment. A log of residual water will be maintained by site personnel.

During the influent and effluent sampling, the liquid volume in the valves and tubing will be purged with approximately 100 milliliters of sample (more than four volumes) into a beaker to ensure a representative sample. This water will be poured into the pilot-test effluent holding tank which will then be pumped into the DPE equalization tank for treatment.

Aqueous waste from HACH® field test kits will be stored in a steel drum on-site. Records of the volume and type of aqueous waste added to the drum will be maintained during the demonstration. This waste will primarily have the characteristics of treated groundwater, but will contain trace amounts of sodium

1 hydrosulfite, sodium metabisulfite, sodium thiosulfate, citric acid monosodium salt, and tri-p-
2 toluenesulfonate from the HACH® iron field test kits and ascorbic acid from the HACH® manganese
3 field test kits.

4 Diluted Alconox® solution from cleaning and decontamination activities will be stored in a 55-gallon
5 drum (Type 1A/2) on-site. In compliance with Section 2.3.1 of the Hazardous Waste Management Plan
6 (SM-ALC-MCAFB INSTRUCTION 32-2. 1996), when the drum is full, the waste will be packaged for
7 pick-up by McClellan AFB. The waste will be labeled, tested, classified, and transferred by a McClellan
8 subcontractor to an on-base conforming storage facility (CSF).

9 Off-gas generated by the pilot plant will pass through a vapor-phase ozone destruction unit, then through
10 sensitive ozone detection monitors which activate system shutdown if any fugitive ozone is detected
11 within the pilot plant. The ozone detection monitors will be set to activate shutdown at ozone concentra-
12 tions of 0.15 ppm. Appendix D contains manufacturer's information on the ozone detection monitors.

13 Due to the adsorptive properties of the C1000 catalyst, organic constituents may be adhered to the cata-
14 lyst at the completion of the demonstration. The C1000 catalyst will be disposed after the pilot test. The
15 estimated amount of catalyst to be disposed is about 60 gallons. At the conclusion of the pilot-scale test,
16 the catalyst will be sampled and characterized in accordance with EPA Method 8260B. The spent cata-
17 lyst will be turned over to the McClellan AFB field team for reuse or disposal as non-hazardous waste (if
18 the catalyst is characterized as non-hazardous), or manifested and disposed as hazardous waste.

19 Solid waste, PPE, and solid waste materials from the HACH® field test kits will be kept in a standard
20 top-lidded drum (Type 1A/2). In compliance with Section 2.3.1 of the Hazardous Waste Management
21 Plan (SM-ALC-MCAFB INSTRUCTION 32-2. 1996), when the drum is full, the waste will be packaged
22 for pick-up by McClellan AFB. The waste will be labeled, tested, and classified by URSG personnel,
23 then transferred by a McClellan subcontractor to an on-base CSF.

24 5.6 DEMOBILIZATION AND SITE RESTORATION

25 URSG personnel will demobilize the pilot plant trailer ensuring the influent and effluent lines and all
26 utilities (electrical, potable water, telephone, oxygen, etc.) are removed properly. System demobilization
27 services include all activities associated with de-installing, packing up, and readying the system for trans-
28 port off-site to the EPS laboratory in Baltimore, Maryland. Used and unused oxygen containers will be
29 picked up by the vendor.

30 Before demobilization, all measurement devices as well as field analyzers will be calibrated to ensure
31 precision, accuracy, and repeatability within the DQO requirements and to determine to what extent any
32 drift occurred in the measurement process. After the trailer is transported off-site, general clean up of the
33 site will be conducted to restore it to its appropriate pre-demonstration condition. The McClellan field
34 team will be contacted prior to disposal of PVC piping and appurtenances to determine if there are any
35 other uses for it.

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6.0 PERMITTING AND REGULATORY COMPLIANCE

6.1 REQUIRED PERMITS

This section describes all applicable or relevant regulatory requirements related to activities discussed in Section 5.0. These requirements include acquisition of permits and compliance with regulations. The necessary permitting and compliance issues are described below.

No permits are required for this demonstration. However, all operations will comply with applicable federal, state, and local regulations for which permits would normally be required. Operations subject to such regulations are discussed below. Furthermore, the waiver of the permitting process does not apply to off-site operations, including the transport of materials or products to the site or off-site. Any activities that will occur off-site are subject to the appropriate permitting procedures.

6.1.1 Hazardous Material Storage

The pilot EC system does not require hazardous materials to support its operation. At the end of the demonstration the catalyst will be tested for hazardous characteristics and properly disposed.

6.1.2 Atmospheric Discharge

No separate permits are required for atmospheric discharge during the demonstration period. The pilot EC system is enclosed; atmospheric discharges from the system include carbon dioxide and ozone and will be passed through an ozone destructor before release to the atmosphere. Since McClellan AFB is a National Priority List (NPL) site, the system will not require any air permits from Sacramento Metropolitan Air Quality Management District (SMAQMD) of the California Air Resources Board (CARB).

6.1.3 Wastewater Discharge

The EC will utilize a slip stream upstream from the DPE treatment system unit located at Site IC 31, treat the water, and return it to the DPE system equalization tank. The equalization tank contents will be treated by the DPE unit which discharges to an IWL connected to the industrial wastewater treatment plan (IWTP). The IWTP discharges to the Sacramento county sanitary sewer. The discharge is governed by permit issued to the base from the county. A comparison between the results of the effluent VOC sampling and the discharge limits presented in the IWTP's permit will be made and included in the final report. No separate permits are required for wastewater discharge during the pilot EC demonstration.

6.1.4 Waste Storage, Treatment, and Disposal

Wastes generated during the operational phase of the demonstration will include (1) used PPE with the arms and legs cut out, and other solid waste (paper towels, rags, etc.) from reactor operation, (2) solid waste from site sampling activities (filters, etc.), and (3) diluted Alconox[®] solution from decontamination activities. The procedures set forth in the Hazardous Waste Management Plan (SM-ALC-MCAFB Instruction 32-2, 1996) will be followed. SM-ALC/EMPC, EMR, EMP and the contracting officer will be notified of the type and quantity of hazardous waste expected to be generated. Hazardous waste will be managed as specified in Chapter 4 of the McClellan AFB Hazardous Waste Management Plan (SM-SLC-MCAFB Instruction 32-2, 1996). No separate permits are required for waste generated during the pilot EC demonstration.

Used Personal Protective Equipment and Other Solid Waste from Operations

Used PPE, with the arms and legs cut out, and towels, rags, etc. that are used for cleaning off probes, reactor parts, etc. will be stored in double-lined plastic garbage bags. When the bags are full, the vapor in these bags will be monitored for contamination with field meters. In the absence of measurable contamination, the bags will be disposed as solid waste in a waste receptacle on base. If contamination is measured above background (ambient air), the PPE waste will be containerized by URSG personnel, and transferred by a McClellan AFB subcontractor to an on-base CSF.

Alconox® Solution

Dilute Alconox® solution from cleaning and decontamination activities will be stored in a 55-gallon drum (1A/2 - full removable head steel drum) on-site. In compliance with Subsection 2.3.1 of the Hazardous Waste Management Plan (SM-ALC-MCAFB Instruction 32-2, 1996), when the drum is full, the waste will be packaged for pick-up by McClellan AFB. The waste will be labeled, tested, and classified by URSG personnel, then transferred by a McClellan AFB subcontractor to an on-base CSF.

PVC Piping

After the test, the influent PVC piping and appurtenances will be disassembled and decontaminated by rinsing the piping with potable water. During the decontamination process, the rinse water will be directed to the IWL for disposal. After the piping is disassembled and decontaminated, the McClellan AFB Field Team will be contacted to determine if there are any uses for the PVC; if so it will be transferred to the Field Team; if not it will be collected, containerized, and disposed as solid waste in a waste receptacle on-base.

Rinsate

After the demonstration is complete, all rinsate used to flush the EC system will be discharged to the DPE for treatment.

6.1.5 General Operation

The general operation of the EC system will require no special or additional permits and will be in compliance with all local, state, and federal codes and regulations.

6.2 REGULATORY COMPLIANCE

In addition to fulfilling the requirements in Subsection 6.1, the implementation and operation of the technology demonstration must comply with other federal, state, and local regulations, including, but not limited to:

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan, requires the implementation of a remedial solution that provides short and long-term effectiveness and permanence, reducing toxicity, mobility or volume through treatment in a cost-effective manner acceptable to federal, state, local personnel and the local community.

- 1 • Resource Conservation and Recovery Act (RCRA) as amended, 42 United States Code
2 (USC) 901 et seq and Title 22 of CCR. No potential RCRA wastes are generated during the
3 EC system operation.
- 4 • Clean Water Act (CWA). The CWA requires compliance with the applicable requirements
5 of the discharge permit issued to the facility by the county. Since the water treated during the
6 demonstration will be discharged back to the DPE influent tank, compliance with the IWTP
7 permit (issued by the county) will not be an issue. Any individual application of the process
8 will need to be evaluated on a case-by-case basis and appropriate surface discharge or other
9 discharge permit requirements met.
- 10 • Safe Drinking Water Act (SDWA) as amended, 42 USC 3300f et seq. Since the treated
11 effluent water will not be utilized for potable uses, the regulation will not be applicable to the
12 demonstration.
- 13 • Clean Air Act (CAA) as amended, Title 42 USC 3401 et seq. Limits the emission of both
14 "criteria" (ozone and its precursors oxides of nitrogen and reactive organic compounds, as
15 well as sulfur dioxide and particulate matter less than 2.5 microns in diameter) and "non-
16 criteria" or hazardous air pollutants. The atmospheric emissions expected are carbon dioxide
17 and ozone. Carbon dioxide is not regulated.
- 18 • Toxic Substances Control Act (TSCA). This regulation is not applicable since TSCA
19 regulated materials are not generated during the operation of the EC system.
- 20 • Mixed Waste Regulations. These regulations are not applicable because the EC unit is not
21 being evaluated for treatment of mixed wastes (e.g., RCRA wastes mixed with radioactive
22 wastes).
- 23 • Federal Insecticide, Fungicide, Rodenticide Act (FIFRA). These regulations are not
24 applicable because the unit will not be used to demonstrate treatment of FIFRA-regulated
25 substances.
- 26 • Occupation Safety and Health Act (OSHA). Since McClellan AFB is a federal site, the
27 operation of the EC system is governed by federal OSHA regulations. This requires the
28 preparation of a site-specific health and safety plan for all work to be conducted on the site.
29 Workers also need to be informed of the nature of the hazards present on the site.
30 Additionally, workers on-site must have successfully completed the OSHA 24-hour health
31 and safety training and attended an annual 8-hour refresher course as outlined in 29 Code of
32 Federal Regulations Part 1910.120 if the site is deemed fully characterized. All equipment
33 used on the site complies with OSHA safety regulations. Since McClellan AFB is located in
34 California, the operation of the EC system will also substantively comply with the regulations
35 contained in Title 8 of California/OSHA.
- 36 • State and Local Regulations. The concerned state and local regulatory agencies include the
37 SMAQMD, the state of California Central Valley Regional Water Quality Control Board
38 (RWQCB), and the state of California Department of Toxic Substance Control (DTSC). No
39 permits are required from these agencies for the demonstration; however, recognizing that all
40 sites have unique characteristics, each potential full-scale application of the technology
41 would need to comply with all applicable state and local regulations promulgated by these
42 agencies.

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7.0 SAMPLING PLAN

This section presents the rationale and procedures for sampling activities proposed during the EC demonstration at Site IC 29. Sample collection is expected to occur over a 3-month period and will be conducted in three phases: site characterization/laboratory-scale testing (two weeks), system optimization (six weeks), and technology demonstration (eight weeks). Appendix E summarizes the sampling and analysis requirements during the laboratory-scale phase of the test; Appendix F summarizes the sampling and analysis requirements during the optimization phase of the pilot-scale test; Appendix G summarizes the sampling and analysis requirements during the operation phase of the pilot-scale test; Appendix H summarizes both the laboratory-scale and pilot-scale sampling and analysis requirements.

7.1 LABORATORY TEST

The laboratory test will consist of conducting a laboratory-scale test of the EC system. For laboratory-scale testing, a sample of the contaminated groundwater will be analyzed upon arrival in the lab to establish baseline data. Since the sample will be shipped in four, 30-gallon drums, each drum will be sampled and a composite sample will be generated. The sample containers will be stored in a cool place within the laboratory and kept tightly sealed before and after required sample volumes are obtained.

Control of Water Sample

As has previously been stated, logistical difficulties associated with collecting and transporting a single 120-gallon grab sample will affect the sample integrity. Therefore, the results of the laboratory sampling will be used only for determining target operating parameters for the optimization phase. To control loss of VOCs during this phase, the laboratory-scale test will be conducted on four 30-gallon batches. These batches will be used one after the other to minimize the head space in each container at any time. In addition, the containers will be kept closed by use of Parafilm® while withdrawing the sample.

Collection of the Composite Feed Sample

The following procedure will be used to generate the composite sample.

- 1) 250 ml of sample will be withdrawn from each of the four drums using a volumetric pipette.
- 2) The sample will be put into a 1000-ml container and mixed.
- 3) The mixed sample will be put into volatile organic analysis (VOA) vials with preservative.
- 4) The vials are labeled and stored in a refrigerator until shipment.

Duplicate samples will be collected from the composite sample and one sample will be sent to EPS, and the duplicate sent to an off-site laboratory; both samples will be analyzed for VOCs by EPA Method 8260B. EPS has elected to submit the samples collected for EPA Method 8260B analysis to Gascoyne Laboratories located in Baltimore, Maryland. The off-site laboratory selected for analysis of the duplicate samples is Curtis & Tompkins, Ltd. (C&T) located in Berkeley, California. The combined sample will also be analyzed by EPS for iron and manganese using HACH® test kits, and a pH field meter, and for total suspended solids (TSS) by C&T. Following the initial analyses, an isotherm test (as described in Subsection 4.4) will be performed.

After developing the adsorption isotherms, a lab reactor containing about 40 grams of catalyst will be filled with wastewater. The purpose of this is to load the catalyst and ensure that the contaminant removal observed in the following test is not due to adsorption of the components. This will be done by

feeding waste water through the reactor without ozone flow until breakthrough of the contaminants is observed. After loading the reactor, the test program will be started.

To conduct the laboratory-scale test, the liquid flow rate through the reactor will be adjusted to provide the desired residence time. The gas flow rate and ozone concentration will also be adjusted to provide the desired ozone dose to the reactor. The reactor will be operated continuously at the selected conditions for at least 15 residence times. Ozone feed gas and off-gas concentration will be monitored continuously using an ozone meter (See Appendix D for ozone meter specifications). Following a minimum of 15 residence times, effluent samples will be collected for analysis. Three subsequent sets of samples, separated by two residence times, will also be collected for analysis. If the analysis of the samples shows that the system was at steady state, the reactor can be adjusted to the next set of conditions. If the analysis shows that the system was not at a steady state, then the sampling will be repeated.

This procedure will be repeated at different conditions to determine optimum operating conditions. The precise process settings will be selected based on the results of the previous test conditions. In general, residence time will be varied to find the shortest feasible residence time and hence the smallest reactor volume. The ozone dose will also be adjusted to determine the lowest effective ozone dose for each residence time. While it is difficult to project with certainty the different ozone dose/residence time combinations that will be used, Table 7-1 provides an initial estimate. Note that both ozone dose and residence time are subject to revision based on initial and subsequent analytical results.

Table 7-1

ESTIMATED LABORATORY-SCALE TEST OPERATING CONDITIONS

Condition	Ozone Dose (mg/l)	Residence Time (min)
1	1000	60
2	500	60
3	500	30
4	250	30

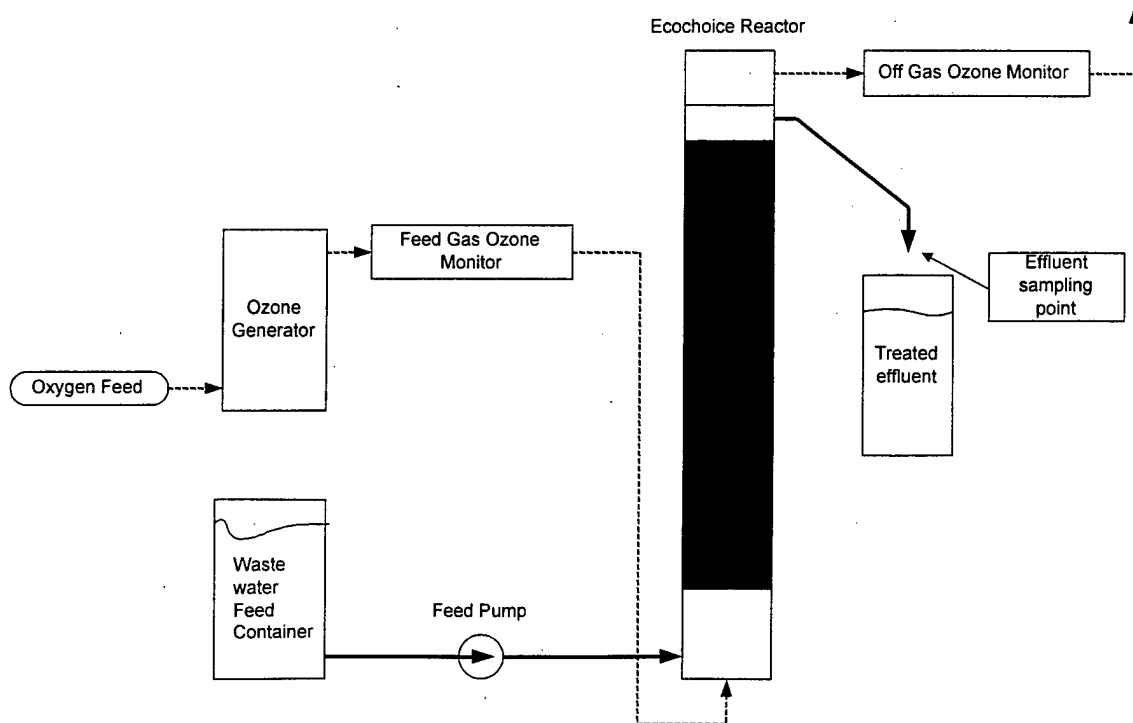
mg/l Milligrams per liter
min Minutes

Appendix E summarizes the sampling plan for the laboratory scale test. Figure 7-1 illustrates a schematic of the laboratory scale test setup show the sample collection points.

EPS senior scientific staff will use professional judgement to determine the pilot-scale test conditions based on the laboratory-scale test results. Any deviations from the previously-described laboratory-scale test operating parameters, along with the rationale for the deviation, will be recorded in the project log book and summarized in the final report.

Figure 7-1

LABORATORY-SCALE CATALYTIC OZONATION FLOW DIAGRAM



Sample Collection Procedures

To collect laboratory samples the following procedures are used:

Feed Sample:

- 1) Using a volumetric pipette, 200 milliliters (ml) of sample are withdrawn from the feed container.
- 2) Two HCl-preserved VOA vials are filled, labeled, and stored in a refrigerator.

Reactor Effluent Sample:

- 1) A 1,000-ml beaker is placed under the reactor effluent tube.
- 2) A minimum of 100 ml (corresponding to more than 15 sample tube volumes) of effluent is purged into the beaker.
- 3) Two VOA vials with preservative are filled with the collected sample.
- 4) The VOA vials are labeled and placed in a refrigerator until analysis.
- 5) Approximately 30 ml of additional sample is collected in a beaker for pH measurement.

7.2 FIELD OPTIMIZATION

Once the mobilization has been completed, the catalyst in the reactor of the pilot plant will be loaded in the same manner as the laboratory reactor was. Specifically, the groundwater is passed through the catalyst without ozone to cause breakthrough of the GAC and allow the effluent concentration of organics to exceed the target discharge concentrations, but not reach influent concentrations. For this demonstration project target discharge concentrations will be defined as the IWTPs discharge permit limits. During this phase of GAC loading, influent and effluent samples will be collected once per day for four days to determine when breakthrough has occurred. These samples will also allow verification of the isotherms developed during the laboratory scale testing (which may not be accurate due to previously-described sample integrity problems associated with the laboratory-scale sample collection and transportation problems).

Once this effluent concentration has been achieved, ozone is added. As oxidation occurs, the effluent concentration will drop and be controlled by the ozone doses and residence times that are applied. It is anticipated that this will require less than one week.

The ozone dose and flow rate will then be adjusted to meet the requirements of Condition 1. Table 7-2 presents estimated conditions which may be changed based upon laboratory results and subsequent field results. The parameters for each condition will be maintained for at least 15 residence times to allow for equalization (steady state) to occur. Since conditions will not be changed until after receipt of valid analytical results, URSG/EPS has conservatively estimated the interval between changes to be a maximum of 7 days. This interval assumes a worst-case scenario of delays in sample transit and analysis, and a subsequent need to collect and analyze a second set of samples. If valid analytical results are received before the end of the equalization period, the conditions will be changed and the additional time added to the operation phase.

Following the determination that steady state has been established, three sets of paired samples will be collected and analyzed for VOCs. The paired sets will include an influent sample (Sample Port PI), followed by a sample from Sample Port 1 (1/3 of the reactor volume), Sample Port 2 (2/3 of the reactor volume) and Sample Port 3 (the effluent of the reactor). Sample port locations are schematically presented in Figure 7-2. Timing of the sample collection will be based on the residence time employed to ensure the integrity of the pairs. As noted above, three sets of VOC samples will be obtained to allow statistical validation of the results. Additional influent and effluent samples will be collected and analyzed for both organic and inorganic parameters.

Details on the sample port, sample identification (ID), and timing for the optimization phase of the test are found in Appendix F. Estimated optimization conditions are presented in Table 7-2. These estimated conditions are subject to revision, based on the results of the initial baseline sampling and the laboratory-scale testing program.

Once these samples have been collected, the ozone dosage and flow rate will be adjusted to meet the requirements of Condition 2. The same procedure noted above will be followed. This pattern will continue through Condition 6.

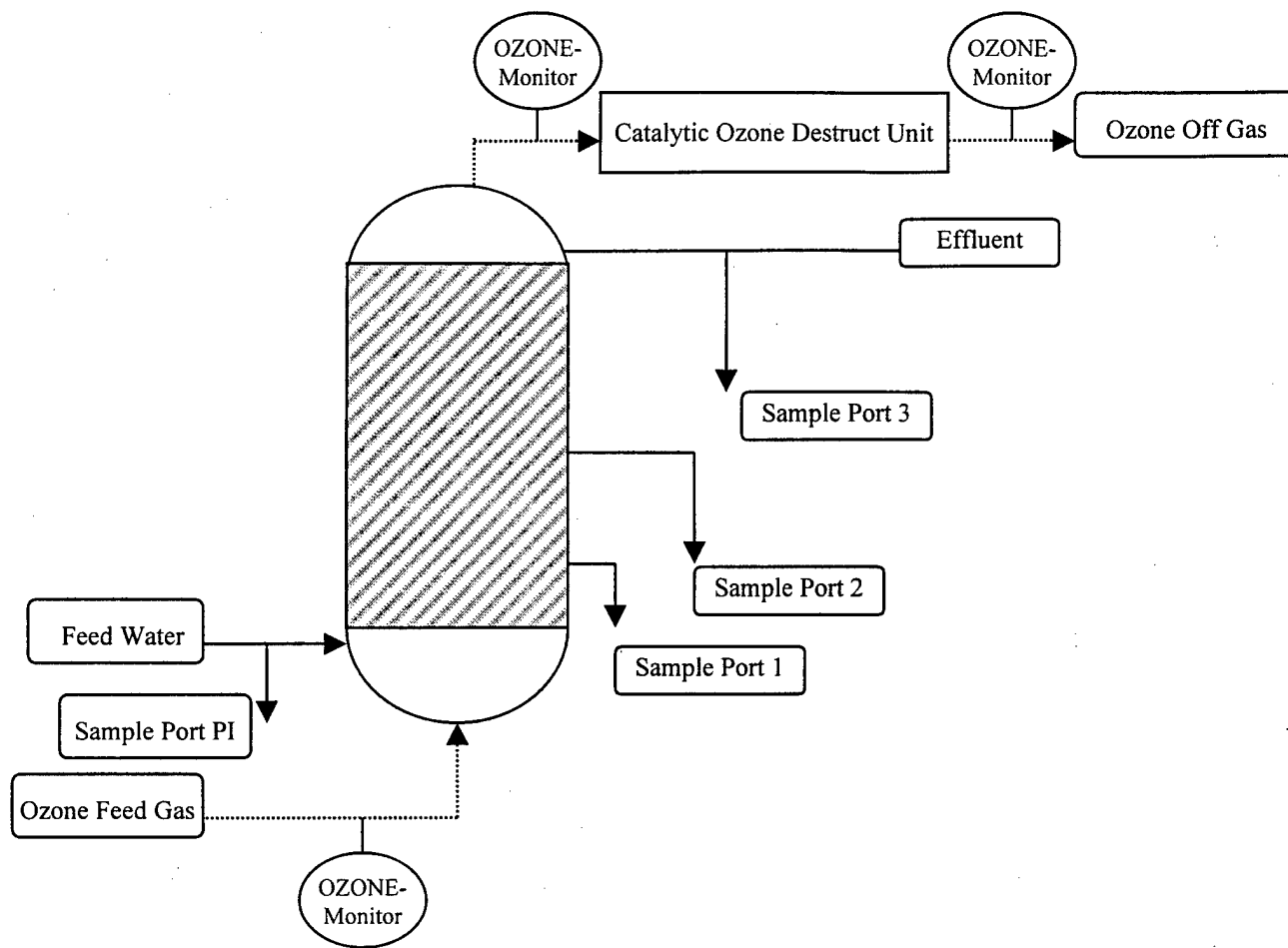
Table 7-2

ESTIMATED OPTIMIZATION CONDITIONS

Condition	Ozone Dose (milligrams per liter)	Residence Time (minutes)
1	750	45
2	700	45
3	700	35
4	650	35
5	600	35
6	550	35

Figure 7-2

EC REACTOR AND SAMPLE PORTS



Sample Collection Procedures

The EC treatment system influent and effluent line are equipped with spigots as sample ports. Each spigot will be purged with a minimum of 20 ml (in excess of 15 sample port volumes) prior to sampling. The appropriate sample containers will be filled directly from the sample ports following spigot purging. The samples will be collected in such a manner as to minimize aeration of the samples. VOC sample containers will be filled first. The samples will be transported to the laboratory as expeditiously as possible. When a 4° C requirement for preserving the sample is indicated, the samples shall be packed in ice or chemical refrigerant to keep them cool during collection and transportation.

7.3 FIELD OPERATION

Once the optimum operating condition has been determined, the system will be adjusted to match that condition, and operate at that condition for a period of at least eight weeks. The length of this operation is to demonstrate reproducibility of performance data, demonstrate adaptability to change groundwater conditions, and to allow for sampling and analysis to meet mandated requirements. During the operation phase VOC samples will be collected and analyzed on a weekly basis to demonstrate the system performance. Additional samples will be collected and analyzed periodically for other inorganic and organic constituents. The previously-described sample collection procedures will be employed during the operation phase. Details on the sample port, sample ID, and timing for the operation phase of the test are found in Appendix G.

7.4 POST DEMONSTRATION

Following the demonstration, three samples of the catalyst will be collected, composited, and a single sample analyzed for target contaminants according to EPA Method 8260B to determine whether the catalyst should be handled as hazardous waste. The following procedure will be used to collect the three catalyst samples. At the conclusion of the demonstration, the top of the reactor will be removed. The catalyst will be vacuumed out and placed in an appropriate container. At three periodic times during this process a sample of the catalyst will be collected. These samples will correspond to approximately the top third, middle third, and bottom third of the reactor. The three samples will be composited to create a representative sample of the spent catalyst for analysis.

See Table 7-3 for all analytic methodology requirements and Appendix H for a summary of all sampling and analysis requirements.

7.5 DATA MANAGEMENT

The data management system for the EC system demonstration has been developed to facilitate the flow of information from the field and laboratory to those persons involved in project decision-making. The objective of a data management system is to provide the user with data sets that have been verified and are internally consistent.

Copies of the field data logbooks and chain-of-custody (COC) forms will be transferred to the Sacramento URSG office for review and correction, if necessary. Once reviewed, field data (sample numbers, sample collection dates, etc.) will be manually entered from these documents into a spreadsheet database. As analytical data arrive from the laboratory, they will be reviewed and any questions, concerns, or dis-

- 1 crepancies resolved prior to validation. The analytical results will then be manually entered into the data-
- 2 base. Printouts from the database will be compared to the field data sheets and analytical reports to iden-
- 3 tify any entry errors. Following this check, the data will then be available for data analysis, statistics,
- 4 plotting, etc.

Table 7-3

ANALYTICAL METHODOLOGY REQUIREMENTS

Analyte Type	Method	Container Type	Container Size	Preservative	Holding Time
Residue Filterable (TSS)	E160.2	Glass or polyethylene bottle	100 ml	Cool: < 4° C	7 days
pH (field measurement)	9040 (electrometric)	Glass or polyethylene bottle	500 ml	NA	NA
Volatile Organic Compounds (VOC) (liquid phase)	8260B	Glass zero headspace with screw cap and septum (VOA vial)	40 ml	HCl: pH<2 Cool: < 4° C	14 days
Total Organic Carbon (TOC) Total Inorganic Carbon (TIC)	E415.2	Glass zero headspace with screw cap and septum (VOA vial)	40 ml	HCl or H ₂ SO ₄ : pH<2 Cool: < 4° C	28 days
TDS	E160.1	Polyethylene	500 ml	None	7 days
BOD ₅	405.1	Glass or polyethylene bottle	1 Liter	None	48 hours
Chloride	E300.0	Polyethylene bottle	500 ml	None	28 days
COD	E410.2	Glass or polyethylene bottle	50 ml	H ₂ SO ₄ : pH,2	28 days
Mn (field measurement)	HACH® TPTZ	Glass or polyethylene bottle	50 ml	NA	NA
Fe (field measurement)	HACH® PAN	Glass polyethylene bottle	50 ml	NA	NA
VOC (gas phase)	TO-14	Summa® Canister	6-Liter	None	None

TSS Total suspended solids
NA Not applicable
Mn Manganese
HCl Hydrochloric acid
mL Milliliter
COD Chemical oxygen demand
H₂SO₄ Sulfuric Acid
Fe Iron
BOD₅ Biological oxygen demand (5-day)
TDS Total dissolved solids
VOA Volatile organic compounds

- 5 All field logbooks and one copy of each COC form will be stored at the field trailer throughout the field
- 6 effort. During demobilization, this information will be transferred to the project files at the URSG Sac-
- 7 ramento office.

- 1 Since the EC system monitoring locations (influent and effluent) do not represent permanent locations at
2 McClellan AFB, no Installation Restoration Program Information Management System (IRPIMS) deliv-
3 erables will be required for this project.
- 4 URSG personnel will deliver samples directly to the laboratory, or to a courier for transportation to the
5 appropriate laboratory (EPS and Gascoyne as the primary laboratories and C&T as the quality assur-
6 ance/quality control [QA/QC] laboratory during the laboratory-scale test phase; C&T as the primary labo-
7 ratory and APPL, Inc. (APPL) as the QA/QC laboratory during the optimization/operation phase). Sam-
8 ples will be accompanied by properly completed COC forms. Sample documentation will be consistent
9 with Section 6.0 of the Basewide Quality Assurance Project Plan (QAPP) (Radian 1997a). A sample
10 COC form is illustrated in Figure 7-3.

CA No. 4367

WORK PLAN FOR PRDA CATALYTIC
OZONATION DEMONSTRATION
McCLELLAN AFB, SACRAMENTO

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8.0 QUALITY ASSURANCE PROJECT PLAN

All QA/QC procedures used for optimization and operation phases of this demonstration project are described in the Basewide QAPP (Radian 1997a). For the laboratory-scale phase VOC analyses EPS will use an alternate laboratory, Gascoyne Laboratory (Gascoyne), Baltimore, Maryland, an EPA-certified laboratory. As previously noted, the purpose of the laboratory analysis is to develop initial field optimization conditions. Both laboratories (Gascoyne for the VOC analyses and EPS for the remaining analyses) will adhere to industry standards for the analytical methods. However, since these data will not be used to evaluate treatment system performance and efficiency analysis in the final report, they will not attempt to adhere to the requirements of the basewide QAPP.

This project-specific QAPP summarizes information from the Basewide QAPP, but does not duplicate information as the Basewide QAPP should be the reference for all work on this project. Project-specific information is provided below.

8.1 PROJECT-SPECIFIC QAPP OBJECTIVES

This project-specific QAPP for the EC system demonstration specifies procedures to ensure analytical data of known quality are generated. These procedures are integral to the demonstration and complement the sampling procedures presented in Section 7.0. Electronic data from the demonstration will be provided to McClellan AFB. Analytical results will be summarized on electronic data sheets and included in the final report.

Both laboratory analytical (definitive data) and field (screening level data) methods will be used to measure EC system performance parameters. The purpose of this QAPP is to outline steps to ensure that:

1. Data generated during the course of the demonstration are of an acceptable and verifiable quality (i.e., quality assurance).
2. A sufficient number of control measurements are taken for proper data evaluation (i.e., quality control).

8.2 MEASUREMENTS

Measurements of water quality, vapor content, and GAC contaminant level will be made to achieve the project's objectives, i.e., to gather quality data to assess performance, operability, and cost-effectiveness, as well as to characterize investigation derived waste (used catalyst) for proper disposal, and process streams (water and vapor) to ensure all are within regulatory limits. The media and target compounds are listed in Table 8-1.

Table 8-1
MEDIA AND TARGET COMPOUNDS

Media	Analyte	
	Organics	Inorganics
Water	VOCs TOC/TIC THM	Manganese Iron pH TSS TDS Alkalinity Ozone BOD5 COD Chlorides
Vapor	VOCs	Ozone
Granular activated carbon	VOCs	None

VOCs Volatile Organic Compounds
TOC/TIC Total Organic Carbon/Total Inorganic Carbon
THM Trihalomethanes
TDS Total Dissolved Solids
TSS Total Suspended Solids
COD Chemical Oxygen Demand
BOD5 Biological Oxygen Demand (5-day)

1 For all water analyses, standard EPA methods will be used:

- 2 • EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846, Third
- 3 Edition, revised November 1986, Update II, September 1994, and Update IIB, January 1995
- 4 and Update III, December 1996.
- 5 • Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater (EPA-
- 6 600/4-85 054)
- 7 • EPA Methods for Analysis of Water and Wastes (EPA-600/4-79-020, 1979)

8 During the laboratory-scale testing, while EPS will serve as the primary analytical laboratory (except for
9 the VOC samples which will be submitted to Gascoyne), and duplicates of 10 percent of the VOC sam-
10 ples will be sent to C&T for analysis. During the optimization and operation phase, C&T will serve as
11 the primary analytical laboratory and duplicates of 10 percent of the VOC samples will be sent to APPL,
12 a California Department of Health Services (DHS)-certified laboratory, located in Fresno, California.

13 **8.3 KEY PERSONNEL**

14 Key personnel for the project and their responsibilities are outlined below.

- Mr. Sarabjit Singh, P.E., is the program manager and principal for the McClellan Environmental Technology Remediation Implementation (METRIC) program. Mr. Singh will have overall responsibility for the project quality and technical integrity.
- Mr. Steven Touchi, P.E., will serve as the project manager, directing the demonstration and will report directly to Mr. Singh. He will be responsible for providing technical direction in the demonstration of the technology, and will work closely with Mr. Ernst Billing. Mr. Touchi will have overall responsibility for the project budget and schedule.
- Mr. Scott Romine will serve as the project engineer and will report directly to Mr. Touchi. He will provide support for all project deliverables.
- Mr. Ernst Billing will be the EPS technical point of contact. He will assist in providing technical direction to the technology demonstration.
- Ms. Kathy Siebenmann or her designee will serve as the senior chemist and QA manager. The responsibilities will include review and analysis of all incoming analytical data for completeness, matching with field COC forms, and overall data quality. Ms. Siebenmann or her designee will also be the liaison with the analytical laboratories on data quality issues.
- Mr. Chris Goodrich will serve as the field services manager. Mr. Goodrich's responsibilities will include performance of day-to-day data gathering, sample gathering, sample shipment, and oversight of field activities during system installation, start-up, and operation.
- Ms. Teresa Morrison will serve as the point-of-contact for C&T, the primary project analytical laboratory. She will be responsible for all laboratory analyses with the exception of the off-gas samples.
- Mr. Mike Ray will serve as the point of contact for APPL, the analytical laboratory responsible for the analysis of the off-gas samples.
- Mr. Francis Patuck will serve as the point of contact for Gascoyne, the analytical laboratory responsible for the analysis of the VOC samples during the laboratory-scale phase.

8.4 PROJECT OBJECTIVES

The purpose of the EC system demonstration is to determine the feasibility and the cost of using an EC system to treat extracted groundwater at McClellan AFB. The project objectives are as follows:

- Demonstrate the ability of the ozone system to obtain removal efficiencies and removal rates for (a) total organics, and (b) chlorinated organic compounds as functions of inlet concentration, catalyst bed hydraulic residence time, and ozone concentration.
- Demonstrate the real-world operating characteristics of a catalyzed ozone treatment system for groundwater pump-and-treat applications.
- Quantify the cost and performance data for the catalyzed ozone treatment system under field conditions encountered at McClellan AFB, comparing the capital and operating costs to those of conventional treatment technologies.

- Verify that the treated effluent from the system meets applicable regulatory requirements for discharge to publicly owned treatment works and surface waters.

To meet those project objectives, individual measurements must meet particular quantitative QA objectives (QAOs) for precision, accuracy, method detection limits, and completeness, as well as qualitative QAOs for comparability and representativeness. Below are the QC samples that will be analyzed to assess the quality of the data for the EC system demonstration.

- Collect and analyze ten percent of the samples as field blanks to evaluate the potential for contamination from ambient conditions or sample collection techniques.
- Collect and analyze ten percent of the samples as field duplicates to assess the homogeneity of samples received by the laboratory as well as the homogeneity of contaminants in the matrix.
- Collect and analyze one trip blank per shipment to evaluate the potential for contamination during shipment.
- Analyze method blanks, laboratory duplicates and control samples, matrix spikes, matrix spike duplicates, and surrogate spikes as required by the specific analytical methodology to determine if QA goals established for precision and accuracy are met for off-site laboratory analyses.

The data generated during the demonstration will be used primarily to assess the effectiveness of the EC system process technology for treating McClellan AFB's extracted groundwater. All on-site analyses (pH, Mn, and Fe) will be produced as screening data. All off-site analytical laboratory measure of VOC concentrations, TOC/TIC, TDS, TSS, BOD₅, ozone, trihalomethanes (THM), chloride, alkalinity, and COD, will produce definitive data.

QAOs have been established to quantitatively evaluate the criteria of precision, accuracy, and completeness. The evaluation of these criteria for definitive data will be based upon sample duplicates, matrix spikes, matrix spike duplicates, and surrogates. The criteria for precision, accuracy, and completeness for all validated data will follow the guidelines established in Section 4.0 of the Basewide QAPP. Evaluation of method detection limits (MDLs) will be in accordance with the procedures outlined in Appendix B to Part 136, "Definition and Procedures for the Determination of Method Detection Limit - Revision 1.1," 40 Code of Federal Regulations (CFR) 136, (1984). Table 8-2 summarizes data quality acceptance criteria and practical quantitation limits (PQLs) for both liquid- and vapor-phase VOCs as presented in the basewide QAPP. The data quality acceptance criteria for completeness for the project will be 95%.

The PQLs presented in Table 8-2 were originally developed for the Basewide QAPP. The RWQCB has issued lower PQLs in association with the NPDES permit. URSG has identified one laboratory, APPL, able to meet the revised PQLs for the contaminants of concern at McClellan AFB, while still complying with the calibration requirements of the Basewide QAPP. A technical memorandum providing additional details is contained in Appendix I.

Table 8-2

DATA QUALITY ACCEPTANCE CRITERIA

Analysis	Compound	LCS % Rec	MS % Rec	MS/MSD Rec	FD RPD	PQL (ppb)	Notes
EPA 8260B	Acetone	32-180	32-180	≤27	≤30	10.0	
	Benzene ^c	75-132	75-132	≤10	≤30	1.0	
	Bromobenzene ^d	50-150	50-150	≤30	≤30	1.0	
	Bromochloromethane ^d	50-150	50-150	≤30	≤30	1.0	
	Bromodichloromethane ^{c,e}	61-143	61-143	≤16	≤30	1.0	
	Bromoform	62-126	62-126	≤17	≤30	1.0	
	Bromomethane ^c	30-110	30-110	≤31	≤30	1.0	
	n-Butylbenzene ^d	50-150	50-150	≤30	≤30	1.0	
	sec-Butylbenzene ^d	50-150	50-150	≤30	≤30	1.0	
	tert-Butylbenzene ^d	50-150	50-150	≤30	≤30	1.0	
	Carbon tetrachloride ^c	70-140	70-140	≤10	≤30	1.0	[a]
	Chlorobenzene ^{c,e}	74-145	74-145	≤12	≤30	1.0	
	Chloroethane	50-150	50-150	≤30	≤30	1.0	
	Chloroform ^c	66-167	66-167	≤16	≤30	1.0	
	1-Chlorohexane ^d	50-150	50-150	≤30	≤30	1.0	[b]
	Chloromethane ^c	13-110	13-110	≤42	≤30	1.0	
	2-Chlorotoluene ^d	50-150	50-150	≤30	≤30	1.0	
	4-Chlorotoluene ^d	50-150	50-150	≤30	≤30	1.0	
	Dibromochloromethane ^c	69-149	69-149	≤13	≤30	1.0	
	1,2-Dibromo-3-chloropropane ^d	50-150	50-150	≤30	≤30	1.0	[a]
	1,2-Dibromoethane ^d	50-150	50-150	≤30	≤30	1.0	[b]
	Dibromomethane ^d	50-150	50-150	≤30	≤30	1.0	
	1,2-Dichlorobenzene ^d	50-150	50-150	≤30	≤30	1.0	
	1,3-Dichlorobenzene ^d	50-150	50-150	≤30	≤30	1.0	
	1,4-Dichlorobenzene ^d	50-150	50-150	≤30	≤30	1.0	
	Dichlorodifluoromethane ^d	50-150	50-150	≤30	≤30	5.0	
	1,1-Dichloroethane ^c	59-139	59-139	≤23	≤30	1.0	
	1,2-Dichloroethane ^c	58-144	58-144	≤26	≤30	1.0	[a]
	1,1-Dichloroethene ^{c,e}	51-145	51-145	≤26	≤30	1.0	[a]
	cis-1,2-Dichloroethene ^d	50-150	50-150	≤30	≤30	1.0	
	trans-1,2-Dichloroethene ^c	63-141	63-141	≤24	≤30	1.0	
	1,2-Dichloropropane ^c	72-135	72-135	≤12	≤30	1.0	
	1,3-Dichloropropane ^d	50-150	50-150	≤30	≤30	1.0	
	2,2-Dichloropropane ^d	50-150	50-150	≤30	≤30	1.0	
	1,1-Dichloropropene ^d	50-150	50-150	≤30	≤30	1.0	
	cis-1,3-Dichloropropene ^c	73-119	73-119	≤14	≤30	1.0	[a]
	trans-1,3-Dichloropropene ^c	17-137	17-137	≤22	≤30	1.0	[a]
	Ethylbenzene ^c	74-144	74-144	≤12	≤30	1.0	
	Hexachlorobutadiene ^d	50-150	50-150	≤30	≤30	1.0	
	2-Hexanone ^d	50-150	50-150	≤30	≤30	5.0	
	Isopropylbenzene ^d	50-150	50-150	≤30	≤30	5.0	[b]

Table 8-2

DATA QUALITY ACCEPTANCE CRITERIA

Analysis	Compound	LCS % Rec	MS % Rec	MS/MSD Rec	FD RPD	PQL (ppb)	Notes
EPA 8260B (Cont'd)	p-Isopropyltoluene ^d	50-150	50-150	≤30	≤30	1.0	
	Methylene chloride ^c	58-128	58-128	≤21	≤30	3.0	
	Napthalene ^d	50-150	50-150	≤30	≤30	1.0	
	n-Propylbenzene ^d	50-150	50-150	≤30	≤30	1.0	
	Styrene ^d	50-150	50-150	≤30	≤30	1.0	
	1,1,1,2-Tetrachloroethane ^d	50-150	50-150	≤30	≤30	1.0	
	1,1,2,2-Tetrachloroethane ^c	66-157	66-157	≤18	≤30	1.0	[a]
	Tetrachlorethene ^c	68-148	68-148	≤11	≤30	1.0	
	Toluene ^{c,e}	77-125	77-125	≤12	≤30	1.0	
	1,2,3-Trichlorobenzene ^d	50-150	50-150	≤30	≤30	1.0	
	1,2,4-Trichlorobenzene ^d	50-150	50-150	≤30	≤30	1.0	
	1,1,1-Trichloroethane ^c	57-145	57-145	≤27	≤30	1.0	
	1,1,2-Trichloroethane ^c	73-123	73-123	≤25	≤30	1.0	
	Trichloroethene ^{c,e}	75-120	75-120	≤11	≤30	1.0	
	Trichlorofluoromethane ^c	43-152	43-152	≤17	≤30	1.0	
	1,1,2-Trichloro-1,2,2-trifluoroethane ^d	50-150	50-150	≤30	≤30	1.0	
	1,2,3-Trichloropropane ^d	50-150	50-150	≤30	≤30	0.5	
	1,2,4-Trimethylbenzene ^d	50-150	50-150	≤30	≤30	1.0	
	1,3,5-Trimethylbenzene ^d	50-150	50-150	≤30	≤30	1.0	
	p-Xylene ^d	50-150	50-150	≤30	≤30	1.0	
	m-Xylene ^d	50-150	50-150	≤30	≤30	1.0	
	o-Xylene ^d	50-150	50-150	≤30	≤30	1.0	
	Vinyl chloride ^c	37-146	37-146	≤35	≤38	1.0	[g]
TO-14	Benzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Bromomethane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Carbon Tetrachloride	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Chlorobenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Chloroethane	76-124	NA ⁱ	NA ⁱ	≤50	4.0	
	Chloroform	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Chloromethane	76-124	NA ⁱ	NA ⁱ	≤50	4.0	
	3-Chloro-1-propene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Chlorotoluene	76-124	NA ⁱ	NA ⁱ	≤50	0.50	[h]
	1,2-Dichlorobenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,3-Dichlorobenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,4-Dichlorobenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Dichlorodifluoromethane (Freon® 12)	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,1-Dichloroethane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,2-Dichloroethane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,1-Dichloroethene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	cis-1,2-Dichloroethene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	

Table 8-2

DATA QUALITY ACCEPTANCE CRITERIA

Analysis	Compound	LCS % Rec	MS % Rec	MS/MSD Rec	FD RPD	PQL (ppb)	Notes
TO-14 (Cont'd)	trans-1,2-Dichloroethene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	[h]
	1,2-Dichloropropane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	cis-1,3-Dichloropropene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	trans-1,3-Dichloropropene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon® 114)	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Ethylbenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Ethylene dibromide	76-124	NA ⁱ	NA ⁱ	≤50	0.50	
	Heptane	76-124	NA ⁱ	NA ⁱ	≤50	0.50	[h]
	Hexachlorobutadiene	76-124	NA ⁱ	NA ⁱ	≤50	4.0	
	Methylene chloride	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Styrene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	[h]
	1,1,2,2-Tetrachloroethane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Tetrachloroethene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Toluene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,2,4-Trichlorobenzene	76-124	NA ⁱ	NA ⁱ	≤50	4.0	
	1,1,1-Trichloroethane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,1,2-Trichloroethane	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Trichloroethene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Trichlorofluoromethane (Freon® 11)	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,2,4-Trimethylbenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,3,5-Trimethylbenzene	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon® 113)	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Vinyl Chloride	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Xylene, o-	76-124	NA ⁱ	NA ⁱ	≤50	2.0	
	Xylenes, m- and p-	76-124	NA ⁱ	NA ⁱ	≤50	2.0	

- a 5 ml purge volume.
- b LCS limits will be used to identify matrix effects.
- c Minimum subset of analytes to be included in LCS.
- d No performance based specifications; limits to be used until data are available.
- e Minimum subset of analytes to be included in MS/MSD.
- f If different surrogates are used, laboratory-based limits will be used and shall have similar recovery limits. If limits of alternate surrogates are not similar, then the surrogates documented here should be used.
- g Did not meet a comparison criterion.
- h Estimated quantitation limit.
- i Matrix spikes are not applicable to analysis of air samples.

FD Field duplicate
LCS Laboratory control sample
MS/MSD Matrix spike/matrix spike duplicate
NA Not applicable
RPD Relative percent difference
NA Denotes not applicable

Qualitative QAOs, comparability and representativeness, will be evaluated using methods described in the Basewide QAPP. Quantitation limits for analytes not listed in Table 8-2 will be in accordance with the Basewide QAPP. Specifically TSS limits are presented in Table 4-3 of the QAPP; VOC limits are presented in Table 4-11a of the QAPP. The field QC samples to be collected are as follows:

- Field duplicates (field duplicate samples and collection duplicates) to indicate variations caused by sampling techniques.
- Trip blanks to indicate contamination of samples during transport.
- Field blanks to indicate contamination introduced through ambient conditions.

8.5 ANALYTICAL PROCEDURES AND CALIBRATION

8.5.1 Analytical Procedures

All laboratory analyses will be performed according to the established methods, as described in the Basewide QAPP and listed in Table 7-3. In summary, those methods are:

- VOCs (water and GAC) by EPA Method SW8260B, Volatile Organics
- TOC by EPA Method 415.2, as described in the Standard Operating Procedure (SOP) in Appendix J
- TSS by EPA Method E160.2
- pH by SW9040 (Electrometric) Method
- Iron by HACH® TPTZ Method
- Manganese by HACH® PAN Method
- VOCs (vapor phase) by EPA Method TO-14
- TDS by EPA Method 160.1
- BOD₅ by EPA Method 405.1
- Chloride by EPA Method 300.0
- COD by EPA Method 410.2

One GAC sample will be analyzed for adsorbed VOCs according to the Method SW5030A specifications for analysis of soil samples using cold (4°C) methanol as the extraction solvent, as referenced by Method SW8260B. Methanol extraction will be conducted in the field at the time of sampling according to McClellan AFB SOP No. McClellan AFB - 026 (Radian 1997a). This method for GAC analysis will first be verified using GAC samples spiked with known quantities of target VOCs. If this method is not appropriately validated for GAC samples, an alternate SOP will be developed using another extraction solvent.

8.5.2 Calibration Procedures and Frequency

All field and laboratory instruments will be calibrated according to manufacturers' specifications. All laboratory instruments will be calibrated in accordance with the McClellan AFB SOP for instrument calibration. Calibration will be performed prior to initial use and after periods of non-use. A record of calibration will be made in the field log book each time a field instrument is calibrated. A separate log book will be maintained by laboratory QA personnel similarly for laboratory instrumentation.

8.5.3 Process Measurements

The URSG instruments used to measure process parameters (e.g., pH, etc.) will be calibrated in accordance with manufacturers' instructions. Flow measuring devices will not be calibrated if calibration

requires the instruments to be sent back to the manufacturer. All other manufacturer-recommended checks of the flow instruments will be performed. The accuracy of the inlet water flow meter will be checked by using a stopwatch to measure the amount of time required to fill a pre-calibrated 5-gallon bucket; the flow rate will then be calculated and compared to the flow meter readings and a correction factor determined. The flow totalizer reading will also be compared to the total volume discharged to the 5-gallon bucket. The instruments will be calibrated at the start and completion of the demonstration. The pH probe will be calibrated daily during the demonstration.

8.5.4 Field Measurements

Calibration curves or checks for all field measurements conducted using field instruments will be performed according to the manufacturer's instructions. A log that documents problems experienced with any instrument, corrective measures taken, battery replacement dates, when used, and by whom, will be maintained for each meter.

8.5.5 Laboratory Measurements

Laboratory calibration procedures will follow the specifications outlined in Section 10.1 of the Basewide QAPP.

8.6 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes procedures for reducing, validating, and reporting data. These procedures follow the requirements in Sections 9.0 and 11.0 of the Basewide QAPP. All validated analytical data generated within the off-site laboratories will be checked for accuracy and completeness by laboratory and project personnel. Records will be kept throughout the analytical process, during data generation, and during reporting so that adequate documentation to support all measurements is available. Record keeping, data reduction, validation, and reporting procedures are discussed in this section.

8.6.1 Data Reduction

Data reduction will follow the requirements contained in the SW 846 and EPA analytical methods cited in Subsection 8.5.1. Reduction involves the reformatting of data to present the desired end-product, i.e., the concentrations of the contaminants. Reformatting will involve the process of performing calculations on the raw data and presenting all values in appropriate units.

The responsibility for data acquisition and reduction of raw data resides with the analysts who perform the analysis. Raw data for the quantitative VOC analytical procedures used during this project will consist of peak areas for surrogates, standards, and target compounds. Analytical results will be reduced to concentration units appropriate for the medium being analyzed: $\mu\text{g/l}$ for water samples, ppm for vapor samples.

8.6.2 Data Validation

Data validation involves a review of the QC data to identify and qualitative, unreliable, or invalid measurements. As a result, it will be possible to determine which samples, if any, are related to out-of-control QC samples. Laboratory data will be screened for inclusion of and frequency of the necessary QC supporting information, such as detection limit verification, initial calibration, continuing calibration, duplicates, matrix spikes, surrogate spikes, and the method and preparation blanks. QC supporting information will be screened to determine whether any datum is outside established control limits. If out-

of-control data are discovered, appropriate corrective action will be determined based upon QC criteria for precision, accuracy, and completeness. Any out-of-control data without appropriate corrective action will be cause to qualify the affected measurement data.

8.6.3 Data Reporting

Data and information generated during the demonstration will be summarized in a Technology Application Analysis Report (TAAR), to be submitted at the completion of the project. QA/QC analysis reports will be generated by laboratory personnel as a product of validation procedures described above. All definitive data analyses will be accompanied by QA/QC data packages as described in the Basewide QAPP. The results from the QA/QC samples will be included in the TAAR, however CLP-type data validation packages will not be included. The ultimate data set produced for project use will consist of all values reported in appropriate units flagged with respective data qualifiers for entry into the project database. All sample results with concentrations between the instrument detection limit and the quantitation limit will be reported. These analytical results will be qualified as estimates and flagged with a "J".

All samples and sample extracts will be retained by the laboratory for 6 weeks following data package submittal.

8.7 INTERNAL QUALITY CONTROL CHECKS

8.7.1 Quality Control Samples

Internal QC data provide information for identifying and defining qualitative and quantitative limitations associated with measurement data. Analysis of laboratory QC samples will provide the primary basis for quantitative evaluation of analytical measurement data quality. Method blanks, laboratory duplicates, matrix spikes, and matrix spike duplicates to determine if QA goals established for precision and accuracy will be met by the analytical laboratory.

The number, type, and frequency of off-site laboratory QC samples will be dictated by the SW846 or EPA methods used by the off-site laboratories. The SW846 and EPA methods shown in Table 7-3 specify the number and types of laboratory QC samples required during routine analysis. This information will be supplied with the data package provided by the laboratory.

8.7.2 Split Samples for Off-Site Laboratory Analysis

Ten percent of the water samples for VOC analysis (using EPA Method 8260B) during the laboratory-scale test conducted by EPS will be collected in duplicate and also analyzed by C&T; the water samples for VOC analysis collected during the optimization and operation tests will be sent to C&T with 10 percent of those samples collected in duplicate and sent to APPL. The samples will be collected according to the methods outlined in the Basewide QAPP. Results from the EPS and C&T laboratories will be compared for precision. The QA objective for precision will correspond to the QA objectives for field duplicates listed in the Basewide QAPP.

8.7.3 Sample Documentation

The on-site field engineer will coordinate with the off-site laboratories for shipment and receipt of sample bottle, coolers, ice packs, COC forms, and custody seals. Upon completion of sampling, the COC will be filled out and returned with the samples to the laboratory. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented. Documentation will be accomplished

through a COC record that records each sample and the names of the individuals responsible for sample collection, transport, and receipt. Sample custody will be initiated by field personnel upon collection of samples.

8.7.4 Sample Identification

A discrete sample identification number will be assigned to each sample. The number will consist of six digits: two digits for the condition number, two digits for the sample point, and two digits for the sample number. For example the first condition, third sample point, second sample would have the number 01-03-02. These discrete sample numbers will be placed on each sample container and will be recorded, along with other pertinent data (such as use of a preservative) in a field notebook dedicated to the project. For blind samples, the sample location will be recorded in the field notebook along with a note indicating that the sample was submitted to the laboratory as a blind sample. Also, the sample label will contain the following information:

- Sampler's initials
- Analysis requested
- Date of collection
- Time of collection
- Preservation (if any)

Chain-of Custody Forms

The URSG COC record is shown in Figure 7-3. The off-site laboratory will supply their own COCs with sample bottles/SUMMA® canisters that are shipped to the site for sample collection. All samples collected for off-site analysis will be physically inspected by the field engineer or field services manager prior to shipment. The COC will be signed by each individual who has the sample in their possession.

Laboratory Sample Receipt

Following sample receipt, the laboratory manager will document sample condition and processing steps applied to the sample per requirements in the Basewide QAPP.

8.8 PERFORMANCE AND SYSTEM AUDITS

Performance Audits. The analysis and data-gathering segments of the EC system demonstration will be checked during performance audits, which may include submitting blind performance evaluation (PE) samples to the laboratories, as necessary throughout the course of the project, to evaluate the effectiveness of each laboratory's QC program. Results of the PE samples will be recorded and compared with routinely-obtained data. A PE sample will be randomly dispersed among samples awaiting analysis to check the analytical procedures.

System Audits. An on-site system audit is a qualitative review that checks that the QC measures outlined in the QAPP are in use; it is a general overview of the whole quality system for the project. A field audit will be conducted on-site at the start of the project and a laboratory audit will be conducted at a point during the field demonstration portion of the program by the URSG QA manager or project manager. Required record keeping following the laboratory audit shall document that all lots were reviewed in the audit report. The audit report shall also identify any deficiencies that were noted. A copy of the audit report shall be included in the final report as an appendix.

1 **8.9 CALCULATION OF DATA QUALITY INDICATORS**

2 The indicators of precision, accuracy, representativeness, completeness, and comparability are defined
3 according to the methods presented in the Basewide QAPP.

4 **8.10 CORRECTIVE ACTION**

5 Corrective action procedures will not deviate from those presented in the Basewide QAPP.

9.0 SITE-SPECIFIC HEALTH AND SAFETY PLAN

9.1 INTRODUCTION

This site-specific health and safety plan (SHSP) defines the health and safety (H&S) requirements for URSG personnel during the completion of tasks and activities associated with the treatability demonstration for the EC system located at Site IC 29.

The SHSP contains information that is applicable to all or most H&S issues related to the EC system demonstration, and subsurface soil and groundwater contaminants associated with Site IC 29, including: field activities and treatment system operations, personnel responsibilities, site hazards, PPE and controls, personal monitoring requirements, site control, decontamination procedures, and emergency response plan. This SHSP presents additional information not addressed in the McAFB Basewide HSP which is a subsection of the McAFB SVE Removal Action Work Plan (RAWP) (URSG 1996a), or the McAFB Site IC 31 SHSP Addendum (URSG 1997). All field team members will be required to read these SHSPs and sign a statement to the effect. Copies of all 3 plans will be maintained at the test site.

The SHSP defines site-specific field activities and personnel, chemical and physical hazards unique to the system to be operated at the Site IC 29/IC 31 treatability demonstration work site, hazard control measures (PPE, engineering), personal monitoring requirements, and emergency response protocols. The requirements and protocols specified in the SHSP take precedence over those presented in the HSP. Nevertheless, **neither the Basewide HSP, IC 31 SHSP Addendum, nor this SHSP are stand-alone documents; all three documents contain important information and represent the H&S program for the work site.**

9.2 BACKGROUND

9.2.1 Technology Description

The EC system, as discussed previously, uses ozone and activated carbon as a catalyst to remove organic groundwater contaminants, such as halogenated VOCs, or chlorinated aliphatics (e.g., TCE, DCE, PCE, TCA). Ozone is bubbled into the groundwater and both the ozone and groundwater contaminants are adsorbed onto the C1000 catalyst. Contaminated groundwater is pumped from several Site IC 29 wells into a 264-gallon holding tank near the EC system trailer. The water is then pumped into one of two reactor chambers located inside the trailer. The reactor chamber contains the activated carbon catalyst which provides the substrate for the oxidation/reduction action. Ozone is generated in an ozone generator from liquid oxygen which is stored outside the trailer in two D45 containers (450 pounds). The ozone is pumped into the reactor where it decomposes into oxygen radicals that react with (oxidize) the adsorbed contaminants. The reaction products desorb from the catalyst surface. The reaction can result in the complete mineralization to H_2O , CO_2 , and inorganic ions (i.e., chloride $[Cl^-]$) which react with minerals in the water (Na^{+1} , Fe^{+2}) to form chloride salts ($NaCl$, $FeCl_2$). The treated water is discharged to the McClellan AFB IWTP. Ozone not used during the process is off-gassed into a thermal ozone destruction unit. All CO_2 and any residual ozone or VOCs are vented to the atmosphere through a 12-foot high stack attached to the EC system trailer.

Ozone concentrations are monitored both within the enclosed treatment system, inside the trailer, and at the stack. The system shuts down automatically if ozone concentrations exceed predetermined optimal levels. The ozone detection monitors will be set to activate shut down at ozone concentrations of 0.15 ppm, unless local OSHA requirements differ.

9.2.2 Site IC 29 Description

Site IC 29 is a 9-acre area located in the southeastern segment of McAFB and the north-central area of OU A, consists of six sites. Data gathered during Phase I RI groundwater sampling indicated that Site IC 29 contaminants were likely contributors to groundwater contamination. Halogenated VOCs, principally TCE (8,600 µg/L), cis-1,2-DCE, carbon tetrachloride, chloroform, and 1,1-DCE, as well as benzene, exceeded drinking water MCLs. TCE was also detected at 14,000 µg/L in MW 224 located west of Building 355.

The most current groundwater data from Site IC 29, indicates that the principal VOC detected was TCE at a concentration ranging from 4,000 to 8,400 ppm, the other VOCs included carbon tetrachloride ranging from 92 to 320 ppm, 1,1-DCE ranging from 100 to 150 ppm, chloroform ranging from 98 to 230 ppm, and cis-1,2-DCE ranging from 66 to 120 ppm. This data is reported on a monthly basis by Radian International (Radian, 1997, 1998).

9.2.3 Purpose of Field Activities

URSG field personnel will be responsible for operating the EC system during installation, optimization, operation and demobilization (total 16 weeks) to demonstrate its treatment effectiveness on contaminated Site IC 29 groundwater. EPS, assisted by Welch Electrical (to make the utility connections) and URSG personnel, will be responsible for the initial setup of the system; verifying all connections to utilities, influent and effluent piping, and liquid oxygen; and ensuring that all components of the system are functioning properly. Thereafter, URSG personnel will be responsible for operating and monitoring the EC system, collecting influent and effluent samples, and monitoring work areas (trailer and work site).

Table 9-1 provides a list of the H&S equipment that will be used or immediately available at the work site during the course of field activities.

9.3 FIELD PERSONNEL

URSG field personnel responsible for the operation of the EC system at the Site IC 29 work site are identified below. Their responsibilities are addressed in the HSP (Basewide RAWP Subsection 8.3) and Section 12 of this WIP.

Team Member	Title
Sarabjit Singh	Program Manager
Steven Touchi	Project Manager
Chris Goodrich	Field Services Manager, Site Safety Coordinator (SSC)
Scott Romine	Project Engineer, Field Operations Coordinator (FOC)

Table 9-1

HEALTH & SAFETY EQUIPMENT CHECKLIST

Personal Protective Equipment (per person)

- X Air-purifying respirator (full- and half-face)
- X Cartridges (organic vapor/acid gas [yellow]; or combination organic vapor/acid gas-HEPA)
- X Safety boots
- X Chemical-resistant boots (PVC/nitrile, neoprene, butyl)
- X Chemical-resistant coveralls (Saranex®, polyethylene)
- X Coveralls (Tyvek® or cotton)
- X Hard hat
- X Face shield
- X Latex gloves (not to be used as chemical-resistant gloves)
- X Nitrile gloves (22 mil., 15 mil., 11 mil)
- X Safety goggles
- X Ear plugs
- X Ear muffs
- Chemical-resistant boot covers (neoprene or butyl)

Misc. PPE/First Aid and Emergency Equipment

- 1 Emergency shower/eyewash
- 1 First aid kit
- X Drinking water
- 2 Fire extinguisher (10 pound UL Rating 4A:80B:C)
- 1 Portable air horn
- 1 Cellular phone
- X Site control equipment: fencing (surrounding work site), cones, barricade tape, placards, signs, etc.

Monitoring/sampling equipment

- 1 Radiation detector
- Oxygen level/CGI
- OVA
- 1 Ozone monitor/sensor
- 1 PID
- Aerosol monitor
- 10 ea Draeger® short-term colorimetric detector tubes (ozone [SKC # 800-33181]; TCE [SKC #800-28541])
- 1 Bellows pump
- 1 Sound level meter
- Personal sampling pump
- Sorbent tubes specify type(s):
- 10 Passive dosimeters/diffusion tubes (ChromAir® ozone colorimetric badges - Labsafety)
- Windsock, wind cone (with ½" or appropriate dia. Pipe)

Decontamination Equipment

- Tub
- X Deionized water
- Garbage can w/liner
- X Buckets (10 gallons)
- X Plastic garbage bags
- 55-gallon drums
- X Brushes
- X Hand pressurized portable water sprayer
- X Detergent (Liquinox®, Alconox®)
- X Paper towels
- 1 Table
- Benches
- Other (specify)

Notes:

- 1 = Quantity of items needed.
- X = Item is necessary, yet total quantity will depend on the usage rate.
- TBD = To be determined.

The demonstration will be conducted under the auspices of URSG's Corporate health and Safety Team. The team is managed by Mr. Mark Litzinger, C.I.H. Since the demonstration will be coordinated out of URSG's Sacramento office, Mr. Jerry Hinck will serve as the local H&S officer who works under the direction of Ms. Mary Lou Sullivan, C.I.H. URSG's Manager of H&S for URSG's Western Region. Mr. Chris Goodrich, as the field service manager, will also serve as the Site Safety Coordinator (SSC), reporting to Mr. Hinck. The H&S organization chart is presented in Figure 9-1.

9.4 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

Training/medical surveillance requirements are addressed in the HSP (Basewide RAWP Subsection 8.4). Specifically for the demonstration:

Pilot Plant Orientation - EPS instructed (includes basic H&S by URSG)

Attendees: URSG and Air Force Field Personnel

Pilot Plant Operations - EPS instructed (includes comprehensive H&S by URSG)

Attendees: URSG Field Personnel

Pilot Plant Sample Collection - EPS instructed

Attendees: URSG Field Personnel

9.5 HAZARD ASSESSMENT

9.5.1 Physical Hazards

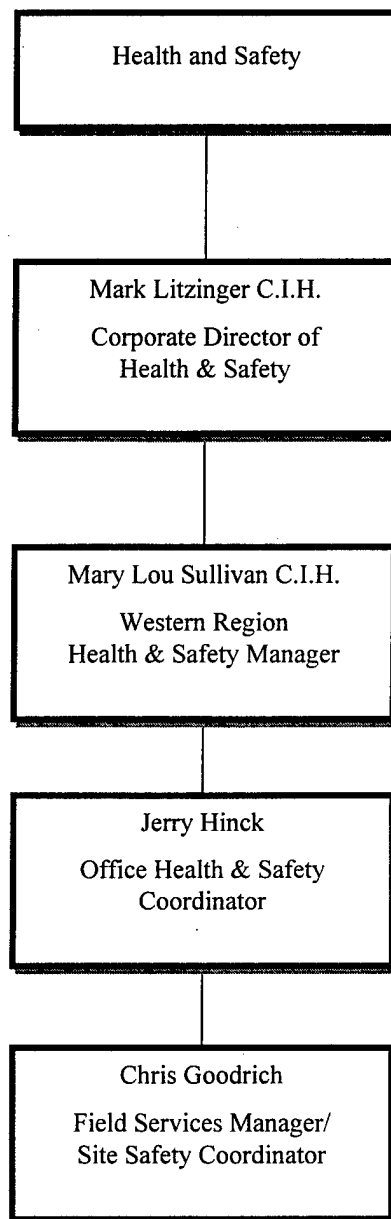
Temperature Extremes. Heat and cold stress hazards and controls are discussed in the HSP (Basewide RAWP Subsection 8.5.2). Although strenuous activities, particularly in impermeable clothing, are not anticipated during the 10-week system treatability test, personnel will be monitored and the work schedule adjusted as necessary during periods of elevated ambient temperatures (30°C or 85 degrees fahrenheit [°F]) or humidity. Activities requiring strenuous labor will, whenever feasible, be scheduled during morning hours.

Although exposure to frequent sub-freezing temperatures is unlikely, cold stress may be an occasional concern when temperatures dip below 4°C (40°F). To help lessen or ease the effects of cold, personnel will be instructed to wear adequately insulated/layered clothing and maintain a change of clothing on-site during periods of inclement weather. All field personnel are provided with rain suits but will be advised to change immediately if clothing gets wet or damp. Since a centrally-located field trailer will be available near the work site, personnel will have a warm sheltered area available for periodic breaks.

Adverse Weather. The SSC, in consultation with the PM or FOC, will determine if outdoor field activities can be continued in a safe manner. In the event of high winds, electrical storms, heavy rain, or visibility-impairing conditions, outdoor activities will be terminated and field personnel will remain inside the trailer until conditions improve. Some outdoor activities may be permitted during inclement weather (rain, wind) but personnel must be alert to possible slip-trip-fall-hazards, and must limit activities to safe areas at ground level.

Figure 9-1

HEALTH & SAFETY ORGANIZATION CHART



1 Noise. Noise level monitoring, and control measures defined in the HSP (Basewide RAWP Subsections
2 8.5.2 and 8.6.3) apply to the EC system and the work site. The blower system at the adjacent Site IC 31
3 SVE system is housed in a noise attenuating enclosure. Consequently, noise levels generated at the work
4 site are not expected to exceed 80 A-weighted scale decibels (dBA). Aircraft operations
5 (landings/takeoffs), the major noise source at the work site, are expected to continue during field
6 activities. Consequently, field personnel are encouraged to wear their hearing protection throughout the
7 work day.

8 Explosive/Flammable Atmospheres. The SSC or SSC-designee will monitor the trailer and the work site
9 for the presence of potentially explosive/flammable atmospheres in accordance with the HSP (Basewide
10 RAWP Subsection 8.6.3). Since liquid oxygen will be stored on site and ozone generated and used in the
11 system, the trailer, pipeline connections, and outdoor air will be regularly monitored with ozone monitors
12 and combustible gas indicators for potentially explosive/flammable atmospheres.

13 Appropriate placards and signs will be posted at the work site to prohibit smoking, open flames, or other
14 combustion sources.

15 Slip, trip, fall hazards. The SSC will ensure that field personnel observe proper site control measures,
16 safe work practices, and keep the trailer and work site free of obstructions. Safety briefings, at a
17 minimum, are to be held on a weekly basis to identify specific areas of concern (e.g., unstable structures,
18 slippery surfaces, protruding pipes) and to specify work practices and controls necessary to avoid or deal
19 with the hazards. The SSC will ensure that field personnel involved in collecting stack gas samples or
20 otherwise using the scaffold are informed of the potential hazards. Non-skid mats, runners, pallets or
21 other appropriate equipment will be used to control slippery surfaces.

22 Electrical Hazards. Electrical hazards are discussed in the HSP (Basewide RAWP Subsection 8.5.1).
23 Additional safety guidelines to be implemented at the system trailer and work site include the following:

- 24 • Lockout/tagout procedures will be implemented during maintenance, servicing,
25 troubleshooting, or other activities conducted on equipment/machinery whose unexpected
26 activation could pose a hazard.
- 27 • Electrical repairs on energized equipment are to be left to electricians and qualified personnel
28 trained to avoid electrical hazards while working on exposed energized parts. When it is
29 absolutely necessary to test energized circuits, the SSC will ensure personnel don appropriate
30 PPE (e.g., rubber gloves, rubber-soled boots, rubber mats, tools with insulated handles),
31 follow manufacturer's operations manual and other specified requirements for the piece of
32 equipment, and remove metal jewelry, watches, or other metals that could act as a conductor.
- 33 • Use of extension cords should be avoided unless absolutely necessary; if used, inspect before
34 each use; never use a cord that appears damaged, defective, or non-waterproof; never use a
35 plug that does not match the receptacle (i.e., two-prong in a three-prong) or modify a plug.
- 36 • All electrical equipment and wires are to be carefully inspected to make sure they are
37 appropriate for the intended use (voltage/current capacity), have proper grounding,
38 insulation, and tight connections.
- 39 • Keep the work area and electrical equipment clean and dispose of potentially flammable
40 materials or wastes (oily rags, paper, etc.).

- Ensure that outlets, circuits, and motors are not overloaded.

Overhead Hazards. Falling objects or overhanging structures are commonly encountered overhead hazards. The outdoor work zone will be designated a hard hat area. All personnel and visitors will be required to wear hard hats in these areas. The SSC will ensure that appropriate warning signs or placards are visibly displayed in all areas of the designated work zone subject to overhead hazards, and at work site entry points. Whenever feasible, obstructions or overhanging structures encroaching commonly used areas posing potential safety hazards will be covered with sufficient padding to protect personnel from possible injury.

Other Hazards. Field personnel may be exposed to other safety hazards such as skeleto-musculature injuries (i.e., strains, sprains, muscle pulls, etc.), tool and equipment hazards, UV radiation (sunburn), and biological hazards (e.g., insect bites). These hazards and appropriate control measures are addressed in the HSP (Basewide RAWP Subsection 8.5.2).

Liquefied oxygen will be stored outside the EC treatment trailer in D45 cylinders. A maximum of two cylinders will be stored in an upright position, chained to a rack designed for this purpose. One cylinder will be used to feed gas-phase oxygen to the ozone generator, while the other cylinder will be on stand-by as a back-up source. The Material Safety Data Sheet (MSDS) for the oxygen and the site specific spill plan are presented in Appendices K and L respectively and will be posted inside the EC treatment trailer. The handling of liquid oxygen is governed by Title 8 of the General Industrial Safety Orders which mandates that when oxygen is stored as a liquid, a non-combustible surface shall be provided in an area extending at least 3 feet from points at ground level upon which leakage of liquid oxygen might fall during operation of the system.

9.5.2 Chemical Hazards

URSG field personnel could be exposed to potential chemical hazards during the 16-week EC system treatability test operations and monitoring/sampling activities as a result of:

- System piping or reactor leaks or uncontrolled vapor/gas releases inside the trailer.
- Leaks in the influent water feed piping or sampling ports.
- Leaks in the ozone generator or ozone piping inside the trailer.
- Residual ozone or VOCs in the system off-gas emissions.

Table 9-2 provides a list of the potential chemical hazards at the treatment system trailer or work site and the permissible airborne levels to which workers may be repeatedly exposed without adverse health effects. The list includes only the most common groundwater contaminants previously detected at IC 29 and chemicals related specifically to the treatment system. The table presents the most stringent permissible exposure levels (PELs), short-term exposure limits (STELs), concentrations considered immediately dangerous to life or health (IDLH), ionization potential of each chemical (to be used as a guideline for selecting the appropriate monitoring instrument), and identifies Proposition 65 chemicals known to the state of California to cause cancer that were detected at Site IC 29.

9.5.3 Cryogenic Hazards

Cryogenic liquids pose several safety concerns in addition to frostbite from extreme cold. Spills of cryogenics rapidly vaporize, producing a gas that is initially significantly more dense than air. In the case of cryogenic oxygen, this can result in a potential overexposure hazard to oxygen in pits, vaults, and enclosed spaces. Given sufficient time, the released oxygen gas reaches equilibrium with its

- 1 surroundings and disperses throughout the available space. During the equilibration period, oxidizable
- 2 compounds should be kept from contact with the released oxygen.
- 3 Personnel handling, connecting, or disconnecting the D45 cylinders should wear a face shield, thermal
- 4 apron, and protective gloves at all times when in contact with the cylinders.

Table 9-2

**POTENTIAL CHEMICAL HAZARDS
AIRBORNE EXPOSURE LIMITS**

Contaminant	PEL ^(a)	STEL ^(b)	IDLH ^(c)	Photoionization Potential ^(d) (eV)
VOLATILE ORGANIC COMPOUNDS (VOCs) (ppm)				
Benzene *	1 Ca, skin	5	500	9.25
Carbon tetrachloride *	2 Ca, skin	200 ^c	200 Ca	11.47
Chloroform *	2 Ca	2	1,000	11.42
1,1-Dichloroethene (vinylidene chloride)	1	NE	NE	10.00
cis-, trans-1,2-Dichloroethene	200	NE	1,000	9.65
Freon® 113 (1,1,2-trichloro-1,2,2-trifluoroethane)	1,000	1,250	2,000	11.99
Trichloroethene * (TCE)	25 Ca	200	1,000	9.45
Non-methane hydrocarbons	300 (gasoline)	500 (gasoline)	NA	NA
INORGANICS (ppm)				
Ozone	0.1	0.3	5	12.52

Notes:

- (a) Most stringent of the federal Occupational Safety and Health Administration (OSHA) or California (Cal)/OSHA Permissible Exposure Limits (PELs) (29 CFR §1910.1000; 8 CCR §5155).
 - (b) STEL (Short-term exposure limit); OSHA and Cal/OSHA 15-minute time-weighted average (TWA) concentration that should not be exceeded unless otherwise noted.
 - (c) IDLH (Immediately dangerous to life or health). National Institute of Occupational Safety and Health (NIOSH) values represent the maximum concentration from which one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects (NIOSH 1994).
 - (d) Ionization potential (IP) provided as guideline for selection of a photoionization (PID) ultraviolet (UV) lamp, and to identify detection limitation (e.g., compounds with IP electronvolt [eV] higher than the eV of the probe lamp will not be ionized [i.e., not detected]).
- * Chemical known to the state of California to cause cancer (22 CCR §12000).
- C Ceiling limit; OSHA and Cal/OSHA concentrations that must not be exceeded during any part of the workday.
- skin "Skin" notation indicates potential for dermal absorption.
- Ca NIOSH (1994) recommends substance be treated as a potential human carcinogen and exposures reduced to lowest feasible concentration.
- NA Not available or applicable.
- NE No level established.
- ppm Parts per million by volume

1 TCE is the most prevalent VOC contaminant in Site IC 29 groundwater. Although unlikely, exposure to
2 TCE or other VOCs through inhalation could result if vapors are released into the breathing space during
3 sampling activities at the EC system sampling ports, vented in the system off gas through the stack, or
4 through leaks in the enclosed groundwater feed pipes, treatment system piping, or reactors. The other
5 chemical hazard at the treatment system trailer and work site is ozone. Exposure inside the trailer could
6 result through leaks in system piping, the reactor, or the ozone generator.

7 Although leaks or uncontrolled releases are highly unlikely in the contained EC system due to the
8 enclosed system and presence of interlocks that would shut down the system to curtail or prevent such
9 occurrences. Nevertheless, site personnel should be aware of the hazards and common symptoms of
10 exposure to VOCs or ozone, such as drowsiness, headache, dizziness, loss of coordination, fatigue,
11 tremors, or irritation of the eyes, nose, or throat. Ozone and VOC levels in the trailer and work site will
12 be monitored throughout the 10-week field activities to determine potential exposures and the need to
13 upgrade the level of PPE. The SSC, or SSC-designee, will monitor the trailer and work site in
14 accordance with HSP provisions (Basewide RAWP Subsection 8.6.3).

15 Dermal exposure to SVOCs, nonvolatile organics, dissolved VOCs, and inorganics in the groundwater or
16 treated effluent water, could occur during sampling activities. Otherwise, exposure to SVOCs and non-
17 volatile contaminants is unlikely unless construction (underground piping, utility connections, other
18 facilities, etc.) and other intrusive activities at the site generate potentially contaminated airborne
19 particulates and dust. Consequently, personnel collecting water samples will wear appropriate PPE,
20 including chemical-resistant gloves, and, if determined necessary by the SSC, rubber apron or coveralls
21 (Saranex®-coated Tyvek®), face-shield, and respiratory protection.

22 Health effects of the VOCs listed in Table 9-2 are presented in the HSP (Basewide RAWP Subsection
23 8.5). Ozone, a powerful oxidizing agent, is a colorless to blue gas with a very pungent odor. Prolonged
24 inhalation exposure can cause irritation of the mucus membranes and eyes. Exposure or contact with
25 elevated concentrations above approximately 2 ppm may cause severe irritation of the eyes and
26 respiratory tract, pulmonary edema, or chronic respiratory disease.

27 Certain chemical materials may be used to decontaminate reusable sampling equipment or as
28 preservatives for water samples. These chemicals may include methanol or hexane decontamination
29 solutions, and dilute acids (hydrochloric acid, nitric acid, sulfuric acid) prepared by and inserted into
30 sample containers by the analytical laboratory. URSG, in accordance with 29 CFR 1920.1200 (Hazard
31 Communication), will maintain MSDS at the treatment system trailer, work site, and/or URSG field
32 trailer for these and all other chemicals used during the system treatability test. Personnel are instructed
33 to refer to the MSDSs for information on the chemical hazards, PPE and special precautions, storage,
34 handling, spill/leak cleanup procedures, and other details about these chemicals. Copies of all MSDSs, as
35 discussed in the HSP (Basewide RAWP Subsection 8.5.1), will also be forwarded to McClellan AFB
36 (652 Medical Group) before hazardous materials are brought on to the work site.

37 9.6 PERSONAL PROTECTIVE EQUIPMENT AND CONTROLS

38 9.6.1 Level of Protection

39 Level D-modified PPE, as identified in the HSP (Basewide RAWP Subsection 8.6.2), will be worn as the
40 initial work uniform for field activities at the work site. Hard hats will not be necessary during operation
41 of the system within the trailer.

PPE for sampling events will be: Level D modified PPE, nitrile gloves, safety glasses with side shields or goggles. PPE for operational changes will be: Level D modified PPE, safety glasses with side shields or goggles.

Additional PPE will be maintained at the work site or URSG field trailer in the event potential eye, dermal, or respiratory hazards are encountered or the level of protection requires upgrading to Level C. This additional Level C PPE will include the following:

- Rubber or neoprene safety boots
- Saranex®-coated Tyvek® coveralls
- Rubber aprons
- Nitrile gloves
- Face shield and safety glasses or goggles
- Full- and half-face air-purifying chemical respirators with organic vapor/acid gas cartridges and dust/mist prefilter, or combination organic vapor/acid gas/high efficiency particulate air (HEPA) cartridges

PPE for handling, connecting, or disconnecting the D45 cylinders will include:

- Face shield and safety glasses or goggles
- Protective gloves
- Thermal apron

9.6.2 Engineering/Administrative Control Measures

Field personnel will be instructed during safety briefings to be aware of potential chemical and physical hazards and to inform the SSC or other supervisory personnel of unsafe conditions or hazards. The SSC is responsible for ensuring that warning signs, placards, barriers, and appropriate site control measures are in place before the onset of operations.

The treatment system includes certain interlocks and system monitors that would shut down the system under predetermined conditions to curtail or prevent potentially dangerous conditions. In addition, an ozone monitor is located within the system trailer to measure ozone concentrations within the enclosed working area. The two D45 oxygen containers will be maintained and secured in a rack located outside the system trailer. EPS will be responsible for ensuring that the oxygen containers are secured and all piping is properly connected. URSG operational personnel will check the containers and piping on a daily basis.

General safety rules as defined in the HSP (Basewide RAWP Subsection 8.6.2, Table 8-4) will be in effect at the work site. These rules are designed to minimize potential work site hazards.

9.7 PERSONAL MONITORING/AIR SAMPLING

Monitoring equipment will include the direct reading instruments (DRIs) and colorimetric detector tubes identified in the HSP (Basewide RAWP Subsection 8.6.3) and included in the site-specific H&S Equipment Checklist presented in Table 9-1. Action levels for the ozone detector, oxygen level/combustible gas indicator (CGI), photoionization detector (PID), color detector tubes, and sound level meter are presented in Table 9-3. If a PID with a 10.2 electron-volt (eV) probe lamp is used, certain compounds with photoionization potentials (PIPs) exceeding that of the PID lamp may not be detected, including carbon tetrachloride (PIP 11.47 eV), chloroform (11.42 eV), Freon® 113 (11.75 to 11.99 eV),

and ozone (12.52 eV). Ozone will be monitored separately with an ozone detector. Due to the limitations of the 10.2 eV probe, either an 11.7 eV lamp or flame ionization detector (FID) may be necessary. If the 11.7 eV PID is used, action levels identified for the PID in Table 9-3 and the HSP (see Basewide RAWP Table 8-5) will still apply.

9.8 SITE CONTROL

The EC system trailer access, security, work zone establishment, site communication system, and buddy system requirements for the work site are addressed in the HSP (Basewide RAWP Subsection 8.7).

9.9 DECONTAMINATION

Personnel and equipment decontamination procedures and requirements for the storage, maintenance, and disposition of any EC system operational and investigation-derived wastes are addressed in the decontamination plan presented in the HSP (Basewide RAWP Subsection 8.8) and Basewide RAWP Section 9.0.

9.10 SPILL/RELEASE CONTROL

The EC system will include process interlocks that will store or prevent any possible leaks or spills from reaching overflow situations extending beyond the work site. The SSC or FOC will ensure that sufficient quantities of sorbent materials, pads, booms or pillows, and other cleanup materials and equipment will be available at the work site to control, neutralize, and clean up small spills. MSDS for the oxygen to be used during the demonstration are included in Appendix K.

In the event of a release of hazardous vapors or gases, operations are to be halted and personnel are to immediately evacuate the work site to an upwind location. The McClellan AFB Fire Department is to be immediately notified. The SSC, PM, or FOC will provide every assistance to help McClellan AFB control and stop the release. The SSC will be responsible for monitoring the work site for the presence of any remaining airborne hazards and, in consultation with McClellan AFB and the PM, determine when it is safe for personnel to return to the work site.

9.11 EMERGENCY RESPONSE PROCEDURES

The procedures addressed in the HSP (Basewide RAWP Subsection 8.9) will apply to the Site IC 29/IC 31 work site. The SSC will post the Emergency Telephone Numbers, included herein as Table 9-4, and the Hospital Location Maps included in the HSP (Basewide RAWP Figures 8-1 and 8-2) at a conspicuous location in the treatment system trailer and work site area. Figure 9-2 shows the emergency and medical facility access route. In the event of an environmental release, personal injury, or adverse event the McClellan AFB PM will be notified as early as possible. A site-specific spill plan for the demonstration is presented in Appendix L.

Table 9-3
ACTION LEVELS

Contaminant/ Hazard (DRI)	Reading*	Action**
Unidentified Vapor or Gas (PID - 10.2 eV or 11.7 eV lamp; FID)	<1 ppm	Continue operations in Level D.
	>1 to <5 ppm (intermittent***)	Continue operations in Level D. Identify vapor with colorimetric detector tube(s) and locate source, monitor continuously.
	>1 to <5 ppm (continuous***)	Requires Level C. Continue operations, check for leaks in treatment system, implement engineering controls, and continue to monitor area with PID
	>5 to <25 ppm (intermittent***)	Shut down EC system, remove personnel, and discontinue operations at the work site. SSC in Level C, to identify vapor/gas, attempt control, and monitor continuously. Operations not to continue until SSC determines it is safe to do so in Level C or Level D PPE. Notify McAFB.
	>25 ppm (continuous***)	Shut down treatment system. SSC or PM to immediately notify and consult with McAFB to determine next course of action.
Ozone (Ozone Detector; Color Detector or Draeger® Tubes)	<0.1 ppm	Continue operations in Level D
	>0.1 to 1 ppm (continuous***)	Level C Required. Continue operations, check for system leaks, implement engineering controls (ventilation), continue to monitor area, and personal exposure with ozone dosimeters
	>1 ppm (continuous***)	Shut down treatment system. SSC, PM to immediately notify and consult with McAFB to determine next course of action.
Oxygen (O₂) Level (O ₂ Meter/Combustible Gas Indicator)	19.5 - 21% O ₂	Continue operations
	Needle deflects upward and then drops to zero	Halt operations and evacuate trailer or work site until readings return to approximately 20%
	>21% O ₂	Halt operations and evacuate trailer or work site until readings return to approximately 20%
	<19.5 O ₂	Halt operations (Level B required) and evacuate trailer or work site until readings return to approximately 20%
Explosive Atmosphere) (O ₂ Meter/Combustible Gas Indicator)	<10% LEL	Continue operations
	10 - 20% LEL	Continue with caution, implement control measures (ventilation)
	>20% LEL	Halt operations and evacuate work site until readings return to <10% LEL
Specific Volatile Organic Compound (VOC) (Ozone Detector; Color Detector or Draeger® Tubes)	>1 ppm, <5 ppm (continuous***)	Chemical-specific; for most VOCs, for VOCs with PEL = 1 (see Table 9-2) upgrade to Level C and continue to monitor with PID and detector tubes
	>5 ppm, <10 ppm (continuous***)	Chemical-specific; for most VOCs, for VOCs with PEL = 5 upgrade to Level C and continue to monitor with PID and detector tubes
	>10 ppm, <25 ppm (intermittent***)	Halt operations. SSC, in level C, to identify source, attempt control and monitor continuously
	>25 ppm (continuous***)	Halt operations and evacuate work site; SSC and PM to determine extent of hazard and how/when to continue. Level B may be required.
Noise Level (Sound Level Meter)	85 dBA (continuous***)	Continue operations
	>85 dBA, <120 dBA (continuous***)	Continue operations wearing combination of hearing protection (i.e., ear plugs, ear muffs) with noise reduction rating (NRR) sufficient to attenuate noise level to 85 dBA
	>120 dBA	Continue operations only if hearing protection sufficient to attenuate noise level to 85 dBA; continue to monitor and initiate acoustical control measures (noise buffers, enclosures, etc.)

* Readings above background levels taken at the worker's breathing zone.

** Action levels for unidentified vapor/gas is based on non-methane compounds; if FID is used, charcoal filter is to be used to distinguish between methane/non-methane compounds.

*** Intermittent = less than one minute; Continuous = more than one minute.

PID Photoionization detector
FID Flame ionization detector
PM Project manager
PEL Permissible exposure limit

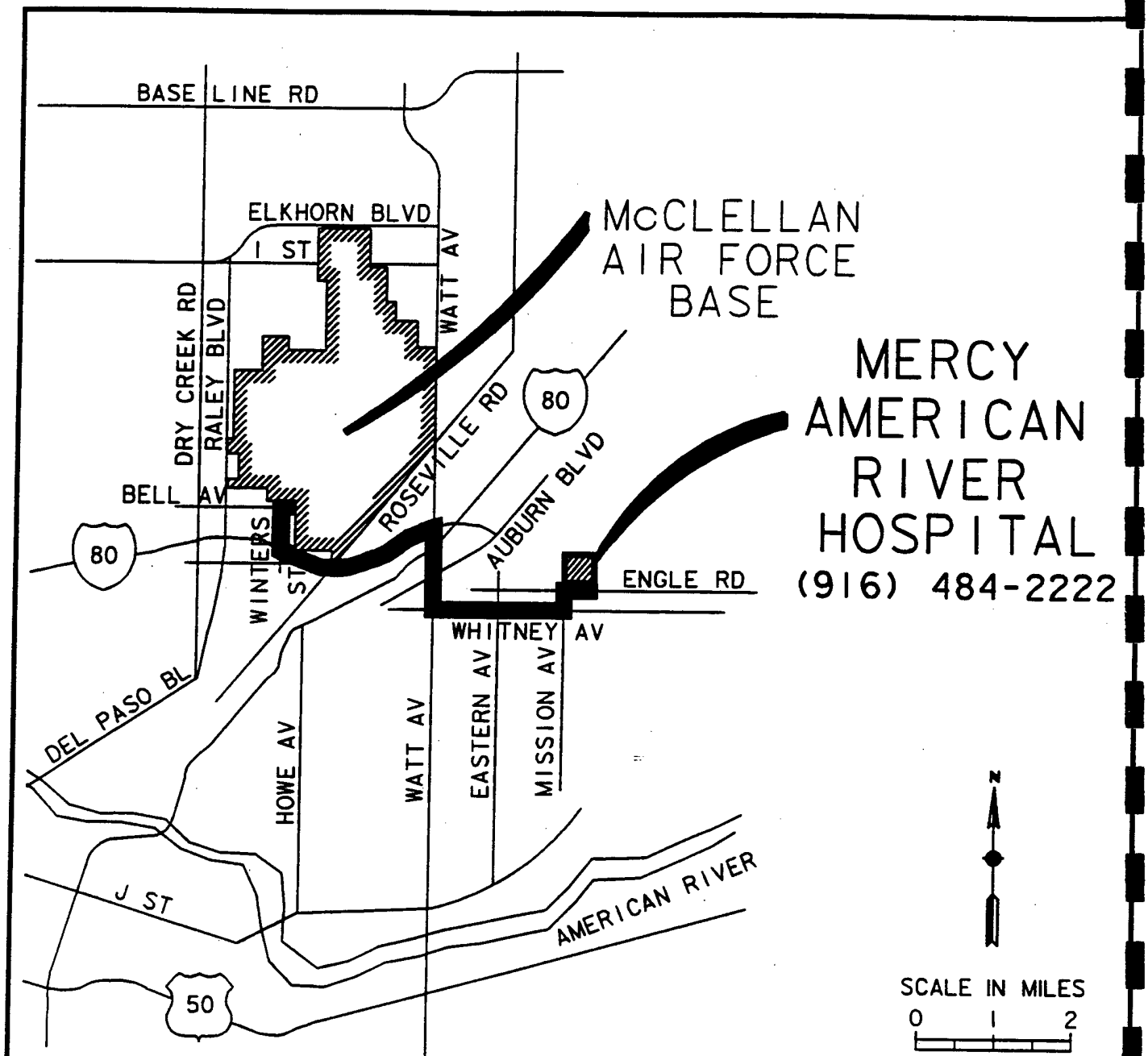
McAFB McClellan Air Force Base
ppm Parts per million
SSC Site safety coordinator

eV Electronvolt
dBA Decibel (A-weighted scale)
LEL Lower explosive limit

Table 9-4

EMERGENCY TELEPHONE NUMBERS

Emergency Assistance (Basic Information)	116 (on base) (916) 643-2111 (off base)
Ambulance	115 (on base)
McAFB Fire Department	117 (on base) (916) 643-6666 (off base)
McAFB Security Police	112 (on base) (916) 643-6168 (off base)
Duty Officer (Command Post)	(916) 643-2751 (off base)
McAFB Safety Office	(916) 643-6227 (off base)
McAFB Medical Clinic (0730 – 1700 hrs, weekdays only)	9916) 643-8420 (off base)
Off-Base Hospital: Mercy American River Hospital 4747 Engle Road Carmichael, CA 95608	(916) 484-2222
Utilities	(916) 643-4875 (off base)
National Response Center (NRC) (Toxic Chemical Releases/Spills)	(800) 424-8802
Regional Poison Control Center (UCD Medical Center – Sacramento)	(916) 734-3692
To telephone McAFB personnel while on base, dial only the last four numbers preceded by a "3" prefix (example: to call <u>643-6168</u> dial <u>3-6168</u>).	



Directions To Mercy American River Hospital 4747 Engle Rd., Carmichael

Exit MoAFB through the Bell Avenue Gate (Gate 660).
 Turn left onto Winters St. and continue south to I-80
 east bound. Continue on I-80 east to Watt Ave. south.
 Turn right onto Watt Ave. and travel south to Whitney Ave.
 Turn left onto Whitney and travel east to Mission Ave.
 Turn left onto Mission Ave. and continue north to
 Engle Rd. Turn right onto Engle Rd. and continue east
 to 4747 Engle Rd.

FIGURE 9.2

EMERGENCY AND MEDICAL
FACILITY ACCESS ROUTE

WORK IMPLEMENTATION PLAN
CATALYTIC OZONATION DEMONSTRATION
McCLELLAN AFB, SACRAMENTO

10.0 TECHNOLOGY APPLICATION ANALYSIS REPORT

The purpose for this demonstration is to obtain data for full-scale operational EC units. Subsequent to the completion of the EC pilot plant demonstration, URSG will prepare a TAAR evaluating the cost and performance of the pilot plant demonstration. An outline of the TAAR is presented below.

1.0 EXECUTIVE SUMMARY

- 1.1 Background
- 1.2 Demonstration Description
- 1.3 Results
- 1.4 Conclusions
- 1.5 Recommendations

2.0 INTRODUCTION AND BACKGROUND

- 2.1 SERDP National Environmental Technology Test Sites
- 2.2 Technology Objectives
- 2.3 Technology Overview
- 2.4 Demonstration Scope
- 2.5 Document Organization

3.0 SITE DESCRIPTION

- 3.1 Site IC 29
 - 3.1.1 Location and Setting
 - 3.1.2 Geology
 - 3.1.3 Hydrogeology
 - 3.1.4 Site History
 - 3.1.5 Site Investigation and Contamination Extent
 - 3.1.6 Removal Action

4.0 DEMONSTRATION DESCRIPTION

- 4.1 Technology Principles
- 4.2 Treatment System Installation and Operation
 - 4.2.1 Well Installation, Drilling, and Sampling
 - 4.2.2 Monitoring System
 - 4.2.3 Instrumentation and Control
- 4.3 The Two Phases of the Technology Demonstration
- 4.4 Sampling Strategy and Quality Assurance/Quality Control (QA/QC) Results
 - 4.4.1 Pre-Demonstration Sampling
 - 4.4.2 Technology Operation
 - 4.4.3 Post-Demonstration Sampling
 - 4.4.4 Shutdown Monitoring
 - 4.4.5 Quality Assurance Sampling
 - 4.4.6 Flow Rate Determination
 - 4.4.7 Sample Containers, Holding Times, and Preservation
- 4.5 Sample Designation
- 4.6 Field Quality Control

5.0 TECHNOLOGY PERFORMANCE EVALUATION

- 5.1 Optimization
 - 5.1.1 Process Stream Characterization
 - 5.1.2 Mass Balance

1	5.2 Remediation Efficiency
2	5.3 Process Flow Efficiency
3	6.0 OTHER TECHNOLOGY ISSUES
4	6.1 Environmental Regulatory Requirements
5	6.1.1 Comprehensive Environmental Response, Compensation, and Liability Act
6	(CERCLA)
7	6.1.2 Clean Air Act (CAA)
8	6.1.3 Resource Conservation and Recovery Act (RCRA)
9	6.1.4 Clean Water Act (CWA)
10	6.1.5 Safe Drinking Water Act (SDWA)
11	6.1.6 Toxic Substances Control Act (TSCA)
12	6.1.7 Mixed Waste Regulations (MWR)
13	6.1.8 Federal Insecticide, Fungicide, Rodenticide Act (FIFRA)
14	6.1.9 Occupational Safety and Health Act (OSHA)
15	6.1.10 State and Local Regulations (SLR)
16	6.2 Personnel Health and Safety
17	6.3 Community Acceptance
18	7.0 COST AND SENSITIVITY ANALYSIS
19	7.1 Basis of Cost Analysis
20	7.2 Cost Categories
21	7.2.1 Mobilization and Preparatory Work
22	7.2.2 Monitoring, Sampling, Testing, and Analysis: Pre-Demonstration and Post-
23	Demonstration
24	7.2.3 Site Work
25	7.2.4 Surface Water Collection and Control
26	7.2.5 Groundwater Collection and Control
27	7.2.6 Air Pollution/Gas Collection and Control
28	7.2.7 Solids Collection and Containment
29	7.2.8 Liquids/Sediments/Sludges Collection and Containment
30	7.2.9 Drums/Tanks/Structures/Miscellaneous Demolition and Removal
31	7.2.10 Biological Treatment
32	7.2.11 Chemical Treatment
33	7.2.12 Physical Treatment
34	7.2.13 Thermal Treatment
35	7.2.14 Stabilization/Fixation/Encapsulation
36	7.2.15 Decontamination and Decommissioning
37	7.2.16 Disposal (Commercial)
38	7.2.17 Site Restoration
39	7.2.18 Demobilization
40	7.3 RESULTS OF COST ANALYSIS
41	8.0 RECOMMENDATIONS
42	9.0 CONCLUSIONS
43	10.0 REFERENCES

11.0 SCHEDULE

- 1
- 2 The schedule for the technology demonstration, including the time period for pre-demonstration
- 3 activities, milestones, and other critical dates or time periods is presented in Figure 11.1.

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12.0 MANAGEMENT AND STAFFING

URSG will conduct the EC demonstration under the oversight of the McClellan AFB Environmental Management (EM) Directorate. Mr. Kevin Wong, of McClellan AFB EM, is responsible for the oversight of the technical effort and is the senior technology advisor. Mr. Larry Jaramillo also of McClellan AFB, is the contracting officer. Mr. Tim Chapman serves as a technical advisor to McClellan AFB. Mr. Jerry Vincent is in charge of the McClellan AFB Team.

C&T will serve as the environmental laboratory for the analysis of the project samples. C&T is a California-certified laboratory. Ms. Teresa Morrison is the point-of-contact for C&T.

Gascoyne will analyze the VOC samples collected during the laboratory-scale testing. Gascoyne is an EPA-certified laboratory. Mr. Francis Patuck is the point-of-contact for Gascoyne.

APPL will serve as the QA/QC laboratory for the duplicate VOC samples collected during the optimization and operation testing, as well as the vapor-phase analyses. APPL is a California-certified laboratory. Mr. Mike Ray is the point-of-contact for APPL.

Welch Electrical will be the electrical and mechanical subcontractor for the demonstration. Steve Welch is a journeyman electrician with direct experience with McClellan AFB installations and existing site conditions. Mr. Welch is also the point-of-contact for Welch Electrical.

12.1 DEMONSTRATION MANAGEMENT PERSONNEL

URSG will be responsible for the overall field demonstration. Responsibility will be shared among key staff assigned to the project. The qualifications and responsibilities of key personnel are below.

Sarabjit Singh P.E. will serve as the principal for the project. Mr. Singh has a B.S. in Chemical Engineering and a Master's in Civil Engineering and is a registered Chemical Engineer. With over 14 years of experience in process engineering, optimization, design, construction and operations of remedial systems, Mr. Singh currently serves as the program manager for METRIC and McClellan Remedial Systems Operations and Maintenance Services (MRS OAMS) contracts. Mr. Singh responsibilities will include project oversight, budget control, final report review, and personnel management for the project.

Steven Touchi, P.E. will serve as the project manager. Mr. Touchi has a B.S. in Chemical Engineering and is a registered Chemical Engineer. He has over 13 years of experience in design installation and operation of remedial systems. Mr. Touchi also has experience with innovative technologies and designing and implementing pilot-scale tests. Mr. Touchi's responsibilities will include liaison with EPS, overall management of field work, and data gathering for the project. Mr. Touchi will be assisted by Scott Romine.

Scott Romine will serve as the project engineer and has a BS in Chemical Engineering and 8 years experience in the design and implementation of remedial technologies. Mr. Romine's responsibilities will include scheduling field activities, data reduction, report preparation and oversight of day-to-day field activities during the demonstration.

Kathy Siebenmann, currently the senior McClellan AFB project chemist will serve as the senior chemist responsible for data quality. She has a Masters Degree in Environmental/Physical Science and over 17 years experience in all aspects of environmental sampling. Ms. Siebenmann's responsibilities will in-

clude review and analysis of all incoming analytical data for completeness, matching with field COC forms, and overall data quality. Ms. Siebenmann will also be the liaison with the analytical laboratory on data quality issues.

Chris Goodrich will serve as the field services manager and has over 10 years experience in technology demonstration including development of scale up factors. Mr. Goodrich's responsibilities will include performance of day-to-day data gathering, sample gathering, sample shipment, and oversight of field activities during system installation, start-up, and operation.

All project personnel are listed in Table 12-1, below. Demonstration subcontractor(s) are listed in Table 12-2. A project organization chart is illustrated in Figure 12-1.

12.2 EPS RESPONSIBILITIES AND QUALIFICATIONS

EPS is an international water treatment technology company providing a full range of technologies and related services to the industrial, municipal and environmental sectors. EPS has primary offices in the U.S., The Netherlands, Germany, and South Africa. EPS was responsible for the largest drinking water plant in The Netherlands. The Project Design and Installation Group is led by Rob Ruis, an experienced project manager who managed the Netherlands installation.

John Johns of EPS will serve as technical liaison and main point of contact for EPS. Mr. Johns has over 10 years experience in all facets of environmental engineering. Mr. Johns holds a B.S. in Petroleum Engineering from the University of Southern California.

Ernst Billing will serve as EPS' technical director for this project. Mr. Billing has 5 years experience in catalytic ozonation water treatment technology with a Ph.D in Chemical Engineering from Michigan Technological University, and a Master's in Chemical Engineering from Dortmund University in Germany.

Table 12-1

DEMONSTRATION MANAGEMENT POINTS-OF-CONTACT

Affiliation	Name/Title	Telephone/Pager
McClellan AFB	Kevin Wong Technology Team Leader	Tel: (916) 643-0830 ext. 459
	Jerry Vincent Field Team Leader	Tel: (916) 643-0830 ext. 447
BDM	Tim Chapman Senior Environmental Engineer	Tel: (916) 643-0830 ext. 412
URS Greiner	Sarabjit Singh Program Manager/Principal	Tel: (916) 929-2346 Pag: (916) 601-6384
	Steven Touchi Project Manager	Tel: (916) 854-2206
	Scott Romine Project Engineer	Tel: (916) 929-2346
	Chris Goodrich Field Services Manager	Tel: (916) 929-2346; Pag: (916) 601-5886

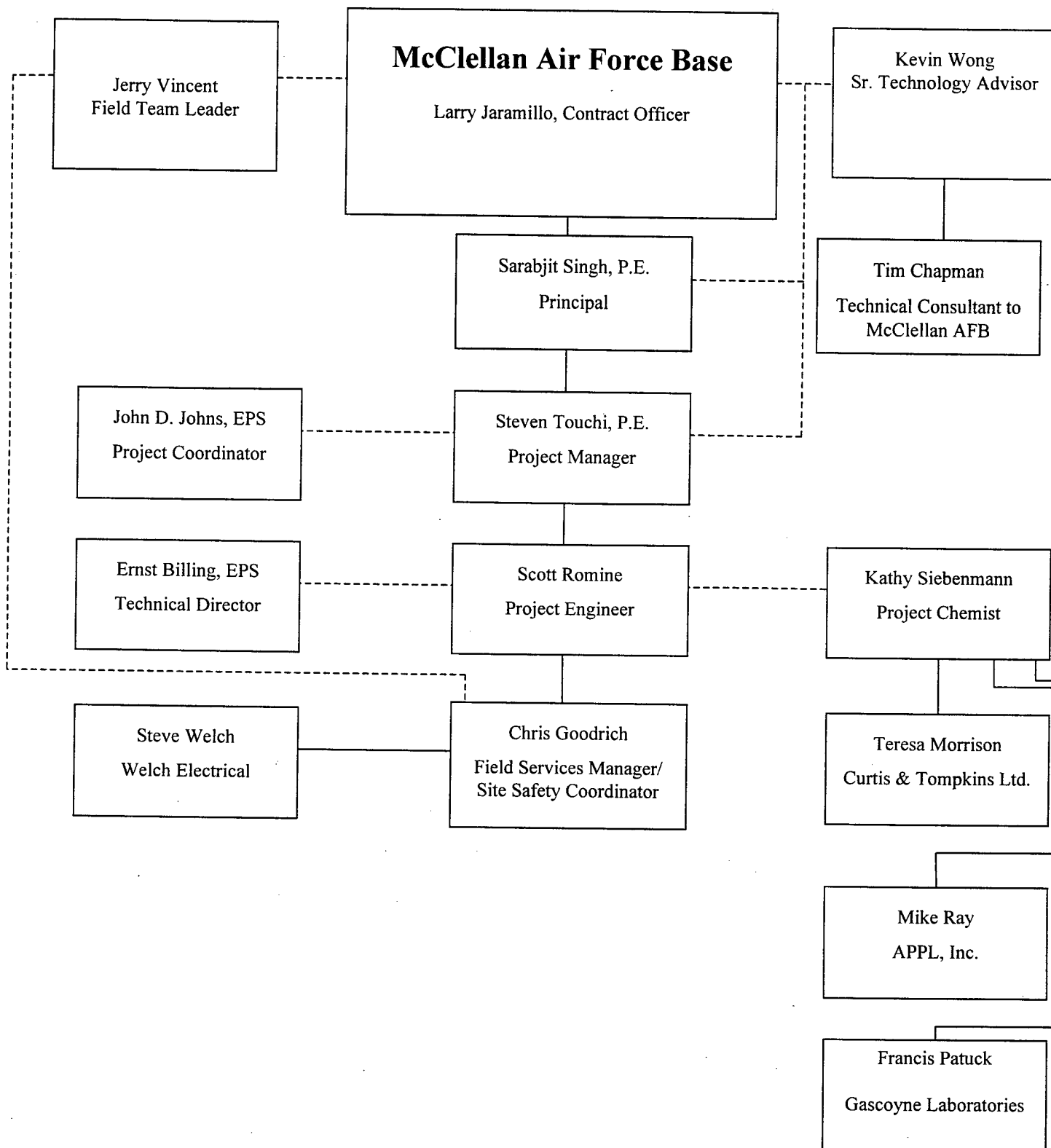
Table 12-2

DEMONSTRATION SUBCONTRACTORS POINTS-OF-CONTACT

Affiliation	Name/Title	Telephone/Pager
ECO Purification Systems	John D. Johns Facilitator Ernst Billing Technical Director	(703) 847-8264 Fax (703) 847-8297 (410) 455-5770 Fax (410) 455-5777
Welch Electrical	Steve Welch President	Tel: (916) 939-3959 Page: (916) 828-9302
APPL, Inc.	Mike Ray	Tel: (209) 275-2175 Fax: (209) 275-4412
Curtis & Tompkins Ltd.	Teresa Morrison	Tel: (510) 486-0900 Fax: (510) 486-0532
Gascoyne Laboratory	Francis Patuck	Tel: (410) 633-1800 Fax: (410) 633-6553

Figure 12-1

PROJECT ORGANIZATION CHART



13.0 REFERENCES

- 1
- 2 Basewide Removal Action Work Plan for Soil Vapor Extraction, McClellan AFB, May 1996,
- 3 Sacramento, URS Greiner.
- 4 Comprehensive Health and Safety Plan, November 1996, METRIC, URSG-Laidlaw.
- 5 D/NEDP Technology Demonstration Plan, ECO Purification Systems USA, Inc., January 6, 1998.
- 6 Jacobs Engineering Group Inc. (Jacobs). 1995. Operable Unit A Site Characterization Summary/Field
- 7 Sampling Plan. Final. November.
- 8 Kaptijn, J.P., M.F.C. Plugge, J.H.J. Annee. 1994. "Water Treatment with a Fixed Bed Catalytic
- 9 Ozonation Process," presented at the International Ozone Association, San Francisco, CA 1994.
- 10 Kaptijn, J.P. 1997. "The ECOCLEAR Process, Results from Full-Scale Installations," Ozone Science
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- 12 McClellan Air Force Base. 1997. Draft Quarterly Groundwater Monitoring Report. 4Q96.
- 13 National Institute for Occupational Safety and Health (NIOSH). 1994. NIOSH Pocket Guide to
- 14 Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. U.S. Department of Health and
- 15 Human Services. Cincinnati OH.
- 16 NETTS, Technology Demonstration Application Analysis Report, Titanium Dioxide Photocatalytic
- 17 Oxidation of Vapors Contaminated With Chlorinated Compounds, September 1997, McClellan
- 18 AFB, URS Greiner, Sacramento, CA.
- 19 8 CCR §5192. Title 8, California Code of Regulations, General Industry Safety Orders, Part 5192 -
- 20 Hazardous Waste Operations and Emergency Response.
- 21 8 CCR §5155. Title 8, California Code of Regulations, General Industry Safety Orders, Part 5155 -
- 22 Cal/OSHA Standards Board Permissible Exposure Limits (PELs) for Chemical Contaminants.
- 23 22 CCR §12000. Title 22, California Code of Regulations, Safe Drinking Water and Toxic Enforcement
- 24 Act of 1986. Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.
- 25 29 CFR §1910.1000. Title 29, Code of Federal Regulations, Subtitle B - Regulations Relating to Labor,
- 26 Chapter XVII - Occupational Safety and Health Administration, Department of Labor, Part
- 27 1910 -Occupational Safety and Health Standards (Cont'd), Subpart Z - Toxic and Hazardous
- 28 Substances, Section 1910.1000 - Air contaminants.
- 29 Radian Corporation (Radian). 1996. Dual Phase Extraction Treatability Study, 100 Percent Report.
- 30 September. 1996.
- 31 Radian. 1997a. Basewide RI/FS Quality Assurance Project Plan Final, McClellan AFB. April.
- 32 Radian International, LLC, November Status Report for the Groundwater Treatment Facilities.
- 33 December. 1997b.

- 1 Radian. 1998. February Status Report for the Groundwater Treatment Facilities. March. 1998.
- 2 URS Greiner, Inc. - California (URSG). 1994. "Health and Safety Program Manual." February.
- 3 URSG. 1998. "Basewide Remedial Action Work Plan for Soil Vapor Extraction, McClellan Air Force
- 4 Base." Final. April.
- 5 URSG. 1997. "IC 29 Addendum to the Site-Specific Removal Action Work Plan for Soil Vapor
- 6 Extraction at Site IC 31, McClellan Air Force Base." Final. September.
- 7 U.S. Army Corps of Engineers (COE). 1992. Safety and Health Requirements Manual. EM-385-1-1.
- 8 Washington D.C.

APPENDIX A

**Summary of Analytical Results from Potential Sites
for ECOCHOICE Demonstration**

DESCRIPTION OF POTENTIAL SITES PER AF

<u>POTENTIAL SITE 1</u>	GWTP UV Ox Stream	Composed from:	<u>Avg. Analysis (Apr. 97)</u>	<u>Influent Level</u>
GWTP=Ground Water Treatment Plant	<u>Technology:</u> UV Oxidation GAC for offgas	EW-73	Chloroform	0.7
		EW-83	1,1 - Dichloroethane	2.68
		EW-84	1,2-Dichloroethane	2.06
		EW-85	1,1-Dichloroethylene	171.52
		EW-86	cis-1,2 - Dichloroethene	8.39
		EW-87	trans-1,2-Dichloroethene	0.2
		EW-305	styrene	nd
		EW-306	tetrachloroethylene	0.54
			1,1,1-Trichloroethane	2
			1,1,2-Trichloroethane	0.28
		Flow: ~117 gpm	Trichloroethylene	323.48
<u>POTENTIAL SITE 2</u>	GWTP LGAC Stream	Composed from:	<u>Avg. Analysis (Apr. 97)</u>	<u>Influent Level</u>
LGAC=Liquid Phase GAC	<u>Technology:</u> LGAC	EW-144	Chloroform	0.38
		EW-137	1,1 - Dichloroethane	nd
		EW-141	1,2-Dichloroethane	nd
		EW-140	1,1-Dichloroethylene	0.33
		EW-307	cis-1,2 - Dichloroethene	7.64
		EW-303	trans-1,2-Dichloroethene	nd
		EW-304	styrene	nd
		EW-310	tetrachloroethylene	0.36
		EW-246	1,1,1-Trichloroethane	nd
		EW-308	1,1,2-Trichloroethane	nd
		Flow: ~644 gpm	Trichloroethylene	57.1
<u>POTENTIAL SITE 3</u>	Dual Phase Treatment System	Composed from:	<u>Avg. Analysis (Apr. 97)</u>	<u>Influent Level</u>
	<u>Technology:</u> Shallow Tray Air Stripper GAC for Offgas	EW-321	1,1-Dichloroethene	130.55
		EW-323	benzene	115.02
		EW-324	carbon tetrachloride	476.88
		MW-224	chloroform	153.14
			cis-1,2 - Dichloroethene	132.50
			methylene chloride	44.71
			trichloroethene	7657.50
			tetrachloroethene	18.70
		Flow: ~33 gpm		
<u>POTENTIAL SITE 4</u>	OU A - Bldg 336	Composed from:	<u>Avg. Analysis (Apr. 97)</u>	<u>Influent Level</u>
	<u>Technology:</u> LGAC	EW-296	carbon tetrachloride	4.4
		EW-297	chloroform	0.8
		EW-298	1,2-Dichloroethane	0.9
			trichloroethene	18
		Flow: ~17 gpm	cis-1,2 - Dichloroethene	0.9
<u>POTENTIAL SITE 5</u>	OU A - Bldg 431	Composed from:	<u>Avg. Analysis (Apr. 97)</u>	<u>Influent Level</u>
	<u>Technology:</u> LGAC	EW-299	carbon tetrachloride	94
		EW-300	chloroform	36
			trichloroethene	1100
		Flow: ~9 gpm	cis-1,2 - Dichloroethene	110
<u>POTENTIAL SITE 6</u>	OU A - Bldg 621	Composed from:	<u>Avg. Analysis (Apr. 97)</u>	<u>Influent Level</u>
	<u>Technology:</u> LGAC	EW-301	chloroform	1.3
		EW-302	1,1 - Dichloroethane	4.8
			1,1 - Dichloroethene	2.2
		Flow: ~17 gpm	trichloroethene	290
			cis-1,2 - Dichloroethene	49
			trans-1,2-Dichloroethene	3.4

APPENDIX B

**Analytical Results from Groundwater Sampling at
the Groundwater Treatment Plant and the Dual
Phase Extraction Unit**

Gascoyne Laboratories, Inc.

YOUR **ON-TIME** QUALITY LAB...

Baltimore, MD 21224

REPORT OF ANALYSIS

(410) 633-1800

(800) GAS-COYN

FAX NO.
(410) 633-5443

www.gascoyne.com

Page 1 of 8

Report No: 9800459

Eco Purification System
1450 S. Rolling Road
Baltimore, MD 21227

Attn: Ernst Martin Billing

This report of analysis contains test results for the following samples submitted to Gascoyne Laboratories, Inc.:

Client Sample I.D.,
DSP-1, 28-Jan-1998(1030)

Sample Type
Groundwater

Lab Sample No.
980001565

Received by
Gascoyne
28-Jan-1998





Gascoyne Laboratories, Inc.

YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

REPORT OF ANALYSIS

(410) 633-1800

(800) GAS-COYNE

FAX NO.
(410) 633-5443

www.gascoyne.com

Page 2 of 8

Report No: 9800459

Eco Purification System
1450 S. Rolling Road
Baltimore, MD 21227

Attn: Ernst Martin Billing

Client Sample I.D.,
UV/OX-1, 28-Jan-1998(1030)

Sample Type
Groundwater

Lab Sample No.
980001566

Received by
Gascoyne
28-Jan-1998

This Report contains the following:

- A) Cover Letter
- B) Test Results
- C) Chain-of-Custody

All samples were analyzed following EPA protocols and other recognized methodologies as specified in the report. All laboratory Quality Control(QC) data associated with this report are within established control limits unless otherwise noted in this report.

Gascoyne Laboratories, Inc. laboratory identification numbers:

Maryland :109; Delaware: MD015; Virginia: 00152; New Jersey: 60637; Pennsylvania: 68-339
West Virginia: 9901(C) and 054; New York: 11158; A2LA: 410.01; AIHA:8885; US Army Corps of Engineers;
and EPA ICR: ICRMD003.

The analyses specified in this report may or may not be included in the scopes of the above listed certifications.

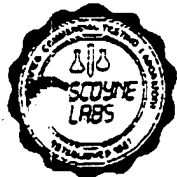
This cover page is an integral part of this report and must be included with all copies of this report.

Final report reviewed by: James H. Newman
James H. Newman, Laboratory Manager

2/4/98
Report issue date



Gascoyne Laboratories, Inc.



YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

REPORT OF ANALYSIS

(410) 633-1800

(800) GAS-COYN

FAX NO
(410) 633-5443

www.gascoyne.com

Page 3 of 8

Report no: 9800459

Client: Eco Purification System

Sample Id: Submitted samples: DSP-1 collected on 28-Jan-98(10:30)

Laboratory Sample Number: 980001565

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Dichlorodifluoromethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Chloromethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Vinyl Chloride	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Bromomethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Chloroethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Trichlorofluoromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1-Dichloroethene	110 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Methylene Chloride	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
trans-1,2-Dichloroethene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1-Dichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
2,2-Dichloropropane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
cis-1,2-Dichloroethene	82 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Chloroform	93 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Bromochloromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1,1-Trichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1-Dichloropropene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Carbon Tetrachloride	250 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Benzene	9 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2-Dichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Trichloroethene	4700 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2-Dichloropropane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Bromodichloromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Dibromomethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
cis-1,3-Dichloropropene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Toluene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
trans-1,3-Dichloropropene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1,2-Trichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2-Dibromoethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Tetrachloroethene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,3-Dichloropropane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)



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Report no: 9800459

Client: Eco Purification System

Sample Id: Submitted samples: DSP-1 collected on 28-Jan-98(10:30)

Laboratory Sample Number: 980001565

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Dibromochloromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Chlorobenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1,1,2-Tetrachloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Ethylbenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Styrene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Bromobenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Isopropylbenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,1,2,2-Tetrachloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2,3-Trichloropropane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Bromobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
n-Propylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
2-Chlorotoluene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,3,5-Trimethylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
4-Chlorotoluene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
tert-Butylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2,4-Trimethylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
sec-Butylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,4-Isopropyltoluene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,3-Dichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,4-Dichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
n-Butylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2-Dichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2-Dibromo-3-chloropropane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2,4-Trichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Hexachlorobutadiene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Naphthalene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
1,2,3-Trichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Total Xylenes	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Acetone	<100 ppb	100 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
2-Butanone	<100 ppb	100 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Vinyl Acetate	<50 ppb	50 ppb	EPA-8260B	JMS	28-Jan-98(21:23)



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Report no: 9800459

Client: Eco Purification System

Sample Id: Submitted samples: DSP-1 collected on 28-Jan-98(10:30)

Laboratory Sample Number: 980001565

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Carbon Disulfide	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:23)
Dibromofluoromethane(surrogate)	95 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:23)
1,2-Dichloroethane-d4(surrogate)	89 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:23)
Toluene-d8(surrogate)	101 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:23)
Bromofluorobenzene(surrogate)	101 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:23)

Sample/Test Notes:

Surrogate out for DF=20 run for Carbon Tetrachloride. Reanalyzed and surrogate out again.

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Report no: 9800459

Client: Eco Purification System

Sample Id: Submitted samples: UV/OX-1 collected on 28-Jan-98(10:30)
Laboratory Sample Number: 980001566

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Dichlorodifluoromethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Chloromethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Vinyl Chloride	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Bromomethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Chloroethane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Trifluoromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1-Dichloroethene	73 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Methylene Chloride	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
trans-1,2-Dichloroethene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1-Dichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
2,2-Dichloropropane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
cis-1,2-Dichloroethene	10 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Chloroform	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Bromochloromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1,1-Trichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1-Dichloropropene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Carbon Tetrachloride	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Benzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2-Dichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Trichloroethene	270 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2-Dichloropropane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Bromodichloromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Dibromomethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
cis-1,3-Dichloropropene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Toluene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
trans-1,3-Dichloropropene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1,2-Trichloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2-Dibromoethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Tetrachloroethene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,3-Dichloropropane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Dibromochloromethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)



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Report no: 9800459

Client: Eco Purification System

Sample Id: Submitted samples: UV/OX-1 collected on 28-Jan-98(10:30)
Laboratory Sample Number: 980001566

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Chlorobenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1,1,2-Tetrachloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Ethylbenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Styrene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Bromoform	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Isopropylbenzene	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,1,2,2-Tetrachloroethane	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2,3-Trichloropropane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Bromobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
n-Propylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
2-Chlorotoluene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,3,5-Trimethylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
4-Chlorotoluene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
tert-Butylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2,4-Trimethylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
sec-Butylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,4-Isopropyltoluene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,3-Dichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,4-Dichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
n-Butylbenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2-Dichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2-Dibromo-3-chloropropane	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2,4-Trichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Hexachlorobutadiene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Naphthalene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
1,2,3-Trichlorobenzene	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
T-Xylenes	<10 ppb	10 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Acetone	<100 ppb	100 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
2-Butanone	<100 ppb	100 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Vinyl Acetate	<50 ppb	50 ppb	EPA-8260B	JMS	28-Jan-98(21:54)
Carbon Disulfide	<5 ppb	5 ppb	EPA-8260B	JMS	28-Jan-98(21:54)



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Report no: 9800459

Client: Eco Purification System

Sample Id: Submitted samples: UV/OX-1 collected on 28-Jan-98(10:30)
Laboratory Sample Number: 980001566

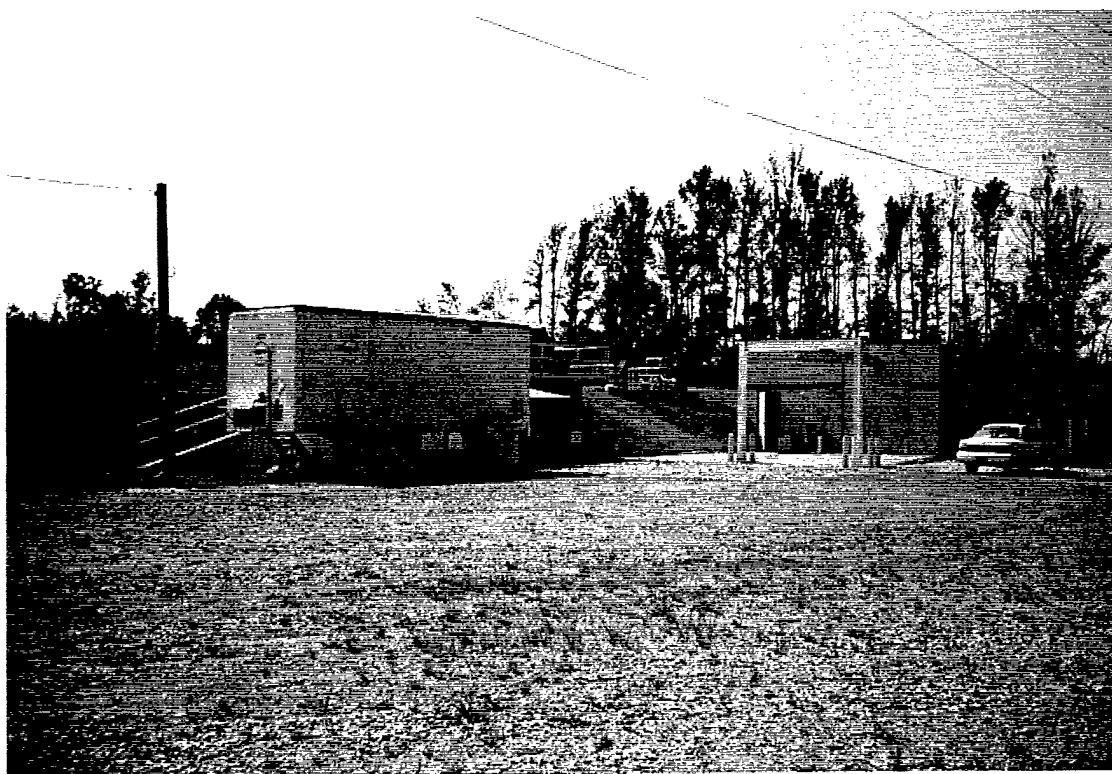
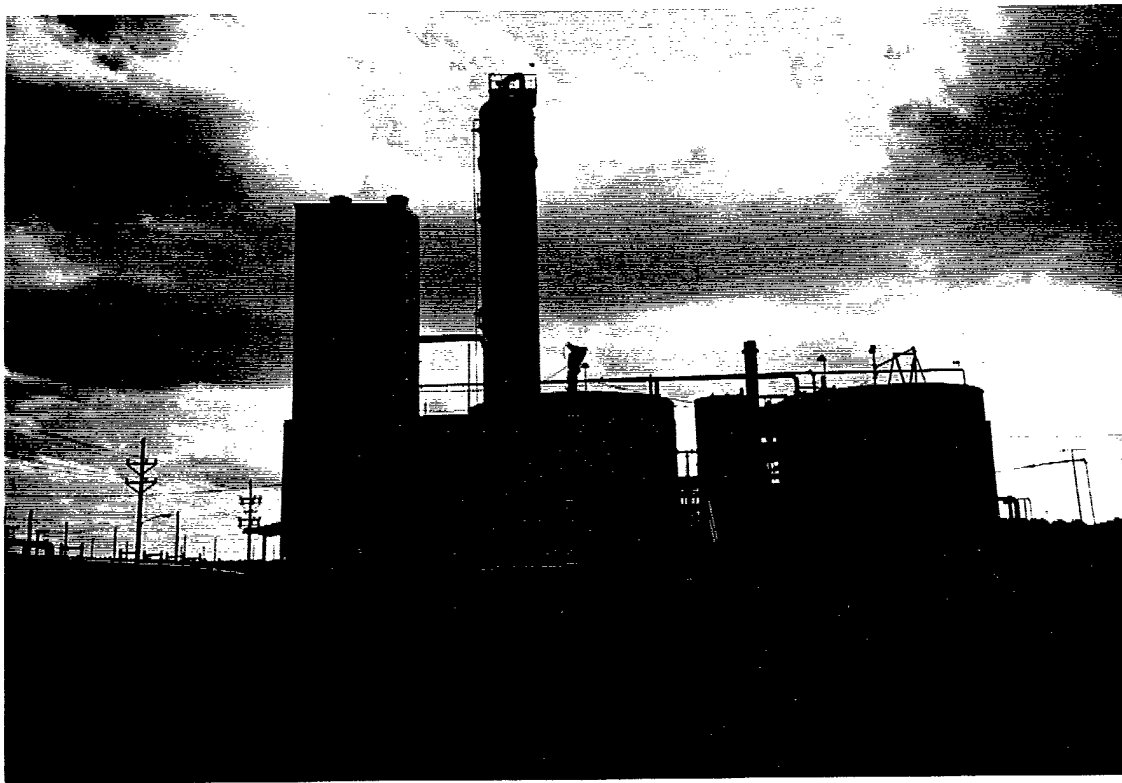
Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Dibromofluoromethane(surrogate)	95 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:54)
1,2-Dichloroethane-d4(surrogate)	95 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:54)
Toluene-d8(surrogate)	99 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:54)
Bromofluorobenzene(surrogate)	102 % Rec	NA	EPA-8260B	JMS	28-Jan-98(21:54)



APPENDIX C

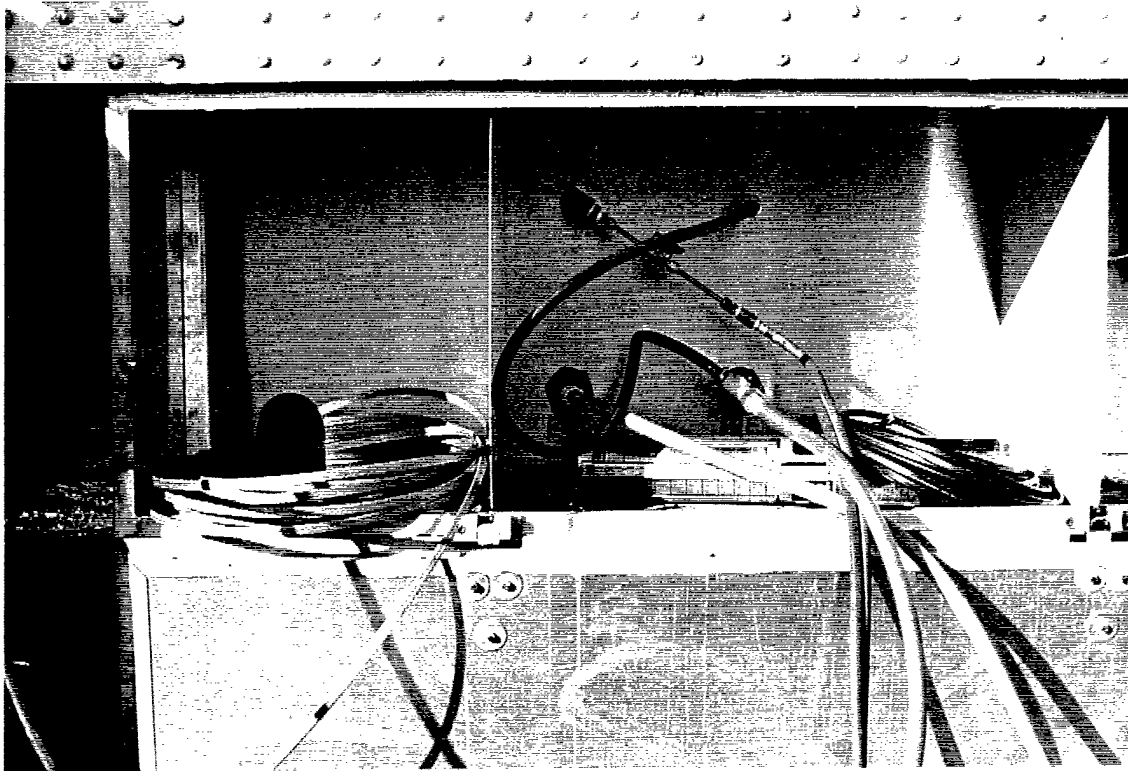
Pilot-Scale Treatment System Trailer Photographs

EXAMPLES OF ECOCHOICE PILOT PLANT PLACEMENT

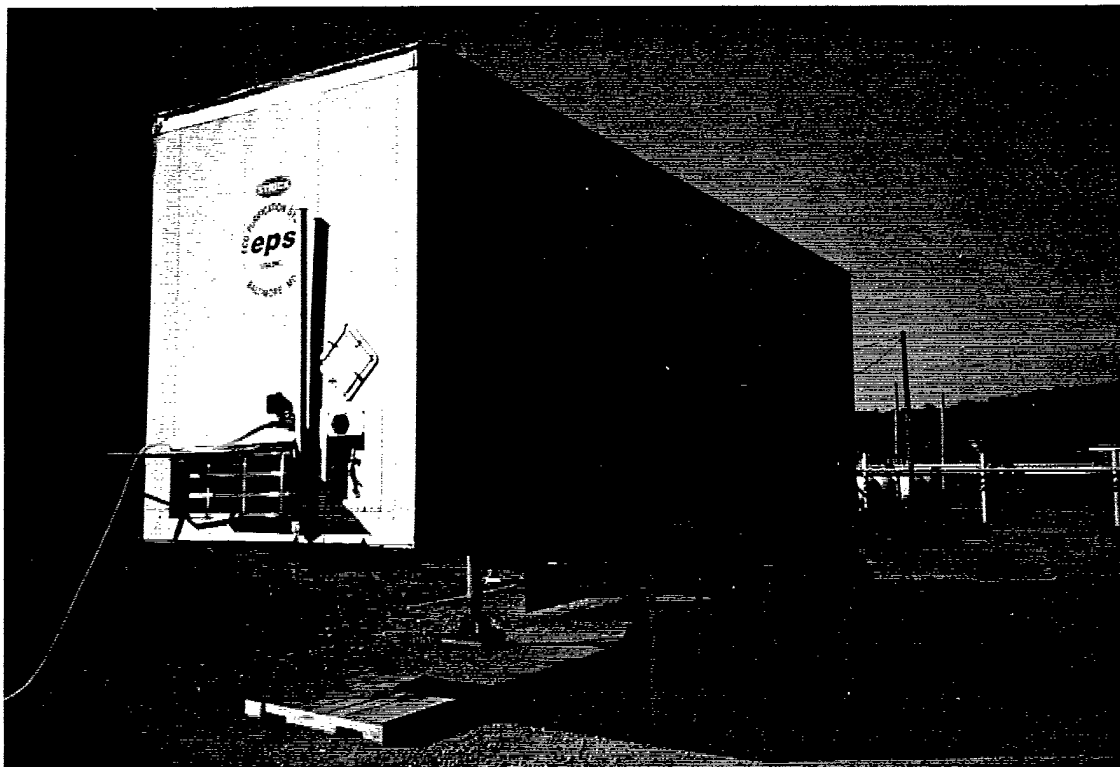


Note Liquid Oxygen Containers Secured to Side

ECOCHOICE PILOT PLANT UTILITY CONNECTIONS

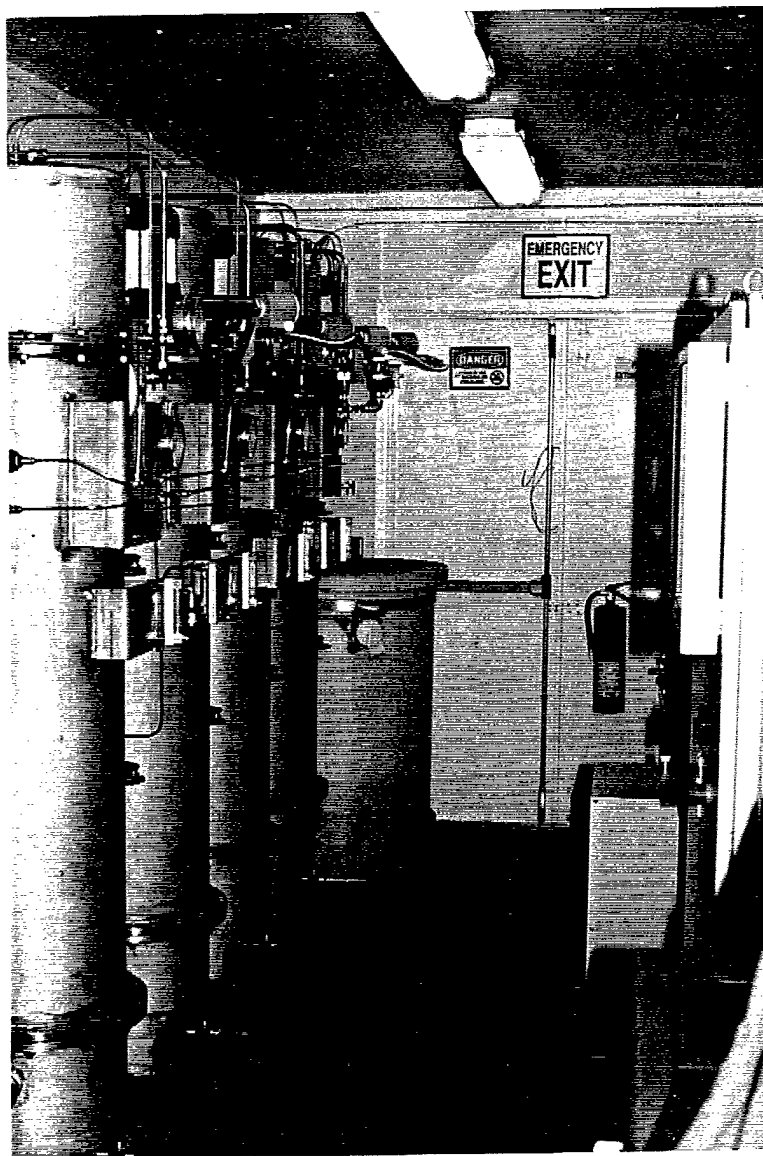


Oxygen, Potable Water, Effluent, Influent as Marked



Small Black Box: Telephone Lines
Yellow Cord Connection: Power

ECOCHOICE PILOT PLANT INTERIOR



Facing the Rear of the Pilot Plant

On Left Side:

Four Reactors

100 Gallon Effluent Holding Tank (with sump pump)

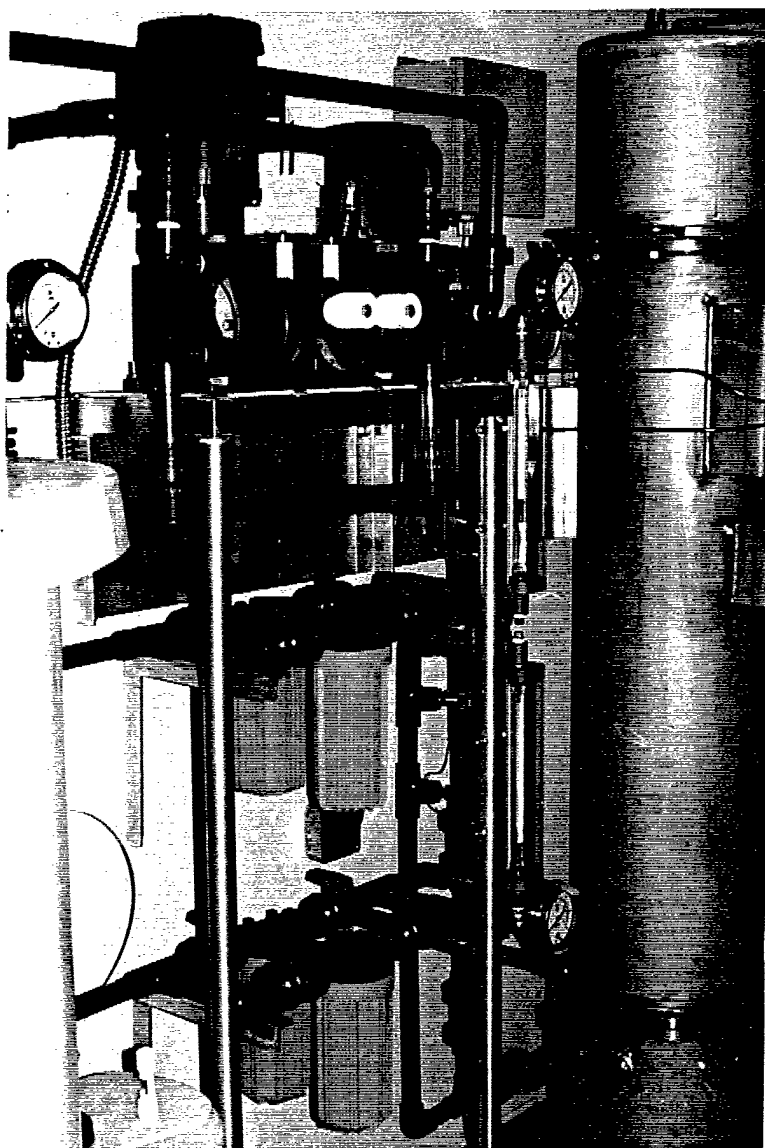
On Right Side:

Sink

Ozone Generator

Chiller

ECOCHOICE PILOT PLANT INTERIOR



Facing the Starboard Side of the Pilot Plant

On Left Side:
250 Gallon Influent Holding Tank

Center:
Process Pumps (green)
Cartridge Filters (blue)

On Right Side:
Reactor

APPENDIX D

Ozone Analyzer Specifications

Product Summary and Key Features

SERIES OR MODEL	DESCRIPTION	MEASUREMENT & CONTROL	TYPICAL RANGE(S)	KEY FEATURES
Series "H" High Concentration Ozone Analyzers	Microprocessor controlled UV absorption ozone analyzer	<ul style="list-style-type: none"> • Generator output • Off-gas (with the appropriate AFX® sample conditioner) 	<ul style="list-style-type: none"> • 0-10% w/w • 0-16% w/w • 0-600 G/M³ 	<ul style="list-style-type: none"> • Continuous sample flow • No solenoid valves • Automatic compensation for sample pressure, temperature & molecular weight • Fail safe operation • Alarms/relays • Allows measurement at high pressures
Series "IN-2000" Single and Multi- Channel Ozone Analyzers (Low to Medium Concentrations)	Microprocessor controlled UV absorption ozone analyzer	<ul style="list-style-type: none"> • Ambient/Safety • Stack monitoring • Test chamber monitoring & control 	<ul style="list-style-type: none"> • 0-1 PPMV • 0-10 PPMV • 0-100 PPMV • 0-1000 PPMV 	<ul style="list-style-type: none"> • Multi channel capability with built-in manifold and programmable sequencer • Fail safe operation • Alarms/relays • Thermostatically controlled UV lamp with control sensor for stability
Series "W" Dissolved and Residual Ozone in Water Analyzers	Microprocessor controlled dissolved ozone analyzer utilizing the transfer technique	<ul style="list-style-type: none"> • Dissolved and residual ozone monitoring & control 	<ul style="list-style-type: none"> • 0-5.00 mg/l • 0-1.000 mg/l 	<ul style="list-style-type: none"> • No consumables - no membranes • Ozone selective • Alarms/relays • Works with most water types
Series "AET-030" Portable Ozone Spot Checker	Microprocessor controlled, thin film semiconductor ozone detector	<ul style="list-style-type: none"> • Leak detection • Spot checking 	<ul style="list-style-type: none"> • 0-1 PPMV 	<ul style="list-style-type: none"> • Hand held • Battery operated • Highly ozone specific • Built-in micro pump

Specifications subject to change without notice

Applications for the AFX® Line of Ozone Instrumentation

OZONE MEASUREMENT	INSTRUMENT SERIES			
	"H"	"IN-2000"	"W"	"AET-030"
Ozone generator output and control	•	-	-	-
Work place safety and ozone leak detection	-	•	-	•
Ozone off-gas monitoring and control	•	•	-	-
Ozone stack monitoring	-	•	-	-
Dissolved and residual ozone	-	-	•	-
Ozone spot checking	-	-	-	•



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APPENDIX E

Laboratory Sampling and Analysis Plan

Laboratory Sampling and Analysis Plan

Condition - Sample ID	SamplePort	Timing	Field Analyses			Laboratory Analyses										Remaining CLIN0005	Offgas VOCs
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS							
Conduct baseline analysis																	
B1	n/a	T	1	1	1	1	1	1	1	1	1	1	1				
B2	n/a	T	1	1	1	1	1	1	1	1	1	1	1				
B3	n/a	T	1	1	1	1	1	1	1	1	1	1	1				
B4	n/a	T	1	1	1	1	1	1	1	1	1	1	1				
Develop isotherms																	
I1	n/a	T + 24 hrs															
I2	n/a	T + 24 hrs															
I3	n/a	T + 24 hrs															
I4	n/a	T + 24 hrs															
I5	n/a	T + 24 hrs															
I6	n/a	T + 24 hrs															
Load catalyst																	
L1	LRE	T+ 5 days															
L2	LRE	T+ 7 days															
L3	LRE	T + 10 days															
L4	LRE	T + 14 days															
Condition 1																	
C1a	LRE	T + 21 days															
C1b	LRE	T + 21 days															
C1c	LRE	T + 21 days															
C1d	LRE	T + 21 days															
Condition 2																	
C2a	LRE	T + 28 days															
C2b	LRE	T + 28 days															
C2c	LRE	T + 28 days															
C2d	LRE	T + 28 days															
Condition 3																	
C3a	LRE	T + 35 days															
C3b	LRE	T + 35 days															
C3c	LRE	T + 35 days															
C3d	LRE	T + 35 days															

Laboratory Sampling and Analysis Plan

Condition - Sample ID SamplePort Timing			Field Analyses			Laboratory Analyses						
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	Remaining CLIN0005	Offgas VOCs
Condition 4												
C4a	LRE	T + 42 days				1		1				
C4b	LRE	T + 42 days				1						
C4c	LRE	T + 42 days				1		1				
C4d	LRE	T + 42 days				1	1					
TOTAL, Laboratory-Scale Phase			4	4	4	30	6	10	3	1	0	0

NOTES:

Timing assumes receipt of sample on a Monday, schedule reflects calendar days, however no activity will occur on weekends.

Fe - Iron

Mn - Manganese

VOCs - Volatile organic compounds

TOC - Total organic carbon

TSS - Total suspended solids

n/a - not applicable

pH by Method SW9040 (electrometric)

Fe by Method HACH PAN

Mn by Method HACH TPTZ

VOCs by Method 8260B

TOC by Method E415.2

TSS by Method E160.2

T - Receipt of drummed groundwater

LRE - Laboratory reactor effluent

(QC) - Quality control sample

Remaining CLIN0005 includes: alkalinity, BOD5, chlorides, COD, ozone, TDS, THM, TIC

Bold indicates 24-hour turnaround required.

APPENDIX F

Field Sampling and Analysis Plan, Optimization

Field Sampling and Analysis Plan - Optimization Phase

Condition - Sample ID	Sample Port	Timing	Field Analyses			Laboratory Analyses							Offgas VOCs	
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	Remaining CLIN0005			
Load catalyst														
LI1		CM + 1 day	1	1	1	1	1	1	1	1	1	1	1	
L1		CM + 1 day	1			1	1	1	1	1	1	1	1	
L2		CM + 1 day				1	1	1	1	1	1	1	1	
LI2		CM + 2 days	1	1	1	1	1	1	1	1	1	1	1	
L3		CM + 2 days	1			1	1	1	1	1	1	1	1	
L4		CM + 2 days				1	1	1	1	1	1	1	1	
LI3		CM + 3 days	1	1	1	1	1	1	1	1	1	1	1	
L5		CM + 3 days	1			1	1	1	1	1	1	1	1	
L6		CM + 3 days				1	1	1	1	1	1	1	1	
LI4		CM + 4 days	1	1	1	1	1	1	1	1	1	1	1	
L7		CM + 4 days	1			1	1	1	1	1	1	1	1	
L8		CM + 4 days				1	1	1	1	1	1	1	1	
Condition 1														
C1-1a	PI1	CM + 7 days	1	1	1	1	1	1	1	1	1	1	1	
C1-1a	1	CM + 7 days				1	1	1	1	1	1	1	1	
C1-2a	2	CM + 7 days				1	1	1	1	1	1	1	1	
C1-3a	3	CM + 7 days	1			1	1	1	1	1	1	1	1	
C1-1b	PI1	CM + 7 days				1	1	1	1	1	1	1	1	
C1-1b	1	CM + 7 days				1	1	1	1	1	1	1	1	
C1-2b	2	CM + 7 days				1	1	1	1	1	1	1	1	
C1-3b	3	CM + 7 days				1	1	1	1	1	1	1	1	
C1-1c	PI1	CM + 7 days				1	1	1	1	1	1	1	1	
C1-1c	1	CM + 7 days				1	1	1	1	1	1	1	1	
C1-2c	2	CM + 7 days				1	1	1	1	1	1	1	1	
C1-3c	3	CM + 7 days				1	1	1	1	1	1	1	1	
C1-OGa	Pre-CDU	CM + 7 days												1
C1-OGb	Post-CDU	CM + 7 days												1
Condition 2														
C2-1a	PI1	CM + 14 days	1	1	1	1	1	1	1	1	1	1	1	
C2-1a	1	CM + 14 days				1	1	1	1	1	1	1	1	
C2-2a	2	CM + 14 days				1	1	1	1	1	1	1	1	
C2-3a	3	CM + 14 days	1			1	1	1	1	1	1	1	1	
C2-1b	PI1	CM + 14 days				1	1	1	1	1	1	1	1	
C2-1b	1	CM + 14 days				1	1	1	1	1	1	1	1	

Condition - Sample ID	Sample Port	Timing	Field Analyses			Laboratory Analyses							
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	Remaining CLIN0005	Offgas VOCs	
C2-2b	2	CM + 14 days				1							
C2-3b	3	CM + 14 days				1							
C2-1c	PI1	CM + 14 days				1	1						
C2-1c	1	CM + 14 days				1							
C2-2c	2	CM + 14 days				1							
C2-3c	3	CM + 14 days				1							
C2-OGa	Pre-CDU	CM + 14 days							1				
C2-OGb	Post-CDU	CM + 14 days											
Condition 3													
C3-1a	PI1	CM + 21 days	1	1	1	1				1			
C3-1a	1	CM + 21 days				1							
C3-2a	2	CM + 21 days				1							
C3-3a	3	CM + 21 days	1			1	1						
C3-1b	PI1	CM + 21 days				1							
C3-1b	1	CM + 21 days				1							
C3-2b	2	CM + 21 days				1							
C3-3b	3	CM + 21 days				1							
C3-1c	PI1	CM + 21 days				1							
C3-1c	1	CM + 21 days				1							
C3-2c	2	CM + 21 days				1							
C3-3c	3	CM + 21 days				1							
C3-OGa	Pre-CDU	CM + 21 days											
C3-OGb	Post-CDU	CM + 21 days											
Condition 4													
C4-1a	PI1	CM + 28 days	1	1	1	1	1			1			
C4-1a	1	CM + 28 days				1							
C4-2a	2	CM + 28 days				1							
C4-3a	3	CM + 28 days	1			1							
C4-1b	PI1	CM + 28 days				1							
C4-1b	1	CM + 28 days				1							
C4-2b	2	CM + 28 days				1							
C4-3b	3	CM + 28 days				1							
C4-1c	PI1	CM + 28 days				1							
C4-1c	1	CM + 28 days				1							
C4-2c	2	CM + 28 days				1							
C4-3c	3	CM + 28 days				1							

Field Sampling and Analysis Plan - Optimization Phase

Condition - Sample ID			Sample Port	Timing	Field Analyses			Laboratory Analyses										Remaining		Offgas	
					pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	CLIN0005	VOCs	Offgas						
C4-OGa		Pre-CDU	CM + 28 days															1			
C4-OGb		Post-CDU	CM + 28 days															1			
Condition 5																					
C5-1a		PI1	CM + 35 days	1	1	1				1											
C5-1a		1	CM + 35 days						1												
C5-2a		2	CM + 35 days																		
C5-3a		3	CM + 35 days	1						1											
C5-1b		PI1	CM + 35 days							1											
C5-1b		1	CM + 35 days																		
C5-2b		2	CM + 35 days																		
C5-3b		3	CM + 35 days							1											
C5-1c		PI1	CM + 35 days							1											
C5-1c		1	CM + 35 days																		
C5-2c		2	CM + 35 days																		
C5-3c		3	CM + 35 days							1											
C5-OGa		Pre-CDU	CM + 35 days															1			
C5-OGb		Post-CDU	CM + 35 days															1			
Condition 6																					
C6-1a		PI1	CM + 42 days	1	1	1				1											
C6-1a		1	CM + 42 days						1												
C6-2a		2	CM + 42 days																		
C6-3a		3	CM + 42 days	1						1											
C6-1b		PI1	CM + 42 days							1											
C6-1b		1	CM + 42 days																		
C6-2b		2	CM + 42 days																		
C6-3b		3	CM + 42 days							1											
C6-1c		PI1	CM + 42 days							1											
C6-1c		1	CM + 42 days																		
C6-2c		2	CM + 42 days																		
C6-3c		3	CM + 42 days							1											
C6-OGa		Pre-CDU	CM + 42 days															1			
C6-OGb		Post-CDU	CM + 42 days															1			
TOTAL, Field Optimization Phase																					
				20	10	10		84	9	44	5	7	0					12			

Field Sampling and Analysis Plan - Optimization Phase

Condition - Sample ID	Sample Port	Timing	Field Analyses			Laboratory Analyses					Offgas VOCs	
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS		Remaining CLIN0005
NOTES:												
Four samples from each condition will be required for statistical evaluation of data.												
The "a", "b", and "c" sets of samples will be collected consecutively, approximately 1 hour apart.												
Fe - Iron												
Mn - Manganese												
VOCs - Volatile organic compounds												
TOC - Total organic carbon												
TSS - Total suspended solids												
CM - Completion of mobilization												
(QC) - Quality control sample												
pH by Method SW9040 (electrometric)												
Fe by Method HACH PAN												
Mn by Method HACH TPTZ												
VOCs by Method 8260B												
TOC by Method E415.2												
TSS by Method E160.2												
Sample Port P1 = Reactor Influent												
Sample Port P1 = 1/3 level of reactor												
Sample Port P1 = 2/3 level of reactor												
Sample Port P1 = Reactor Effluent												
Sample Port Pre-CDU = Prior to Catalytic Destruct Unit (ozone)												
Sample Port Post-CDU = After Catalytic Destruct Unit (ozone)												
Remaining CLIN0005 includes: alkalinity, BOD5, chlorides, COD, ozone, TDS, THM, TIC												
Bold indicates 24-hour turnaround required.												

APPENDIX G

Field Sampling and Analysis Plan, Operation

Field Sampling and Analysis Plan - Operation Phase

Condition - Sample ID	Sample Port	Timing	Field Analyses			Laboratory Analyses								Offgas VOCs	
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	Remaining CLIN0005				
Optimum Condition															
OC-1-1a	PI	CO + 7 days						1							
OC-1-3a	3	CO + 7 days						1							
OC-1-1b	PI	CO + 7 days						1							
OC-1-3b	3	CO + 7 days						1							
OC-1-1c	PI	CO + 7 days						1		1					
OC-1-3c	3	CO + 7 days						1		1					
OC-1-OGa	Pre-CDU	CO + 7 days													
OC-1-OGb	Post-CDU	CO + 7 days													
OC-2-1a	PI	CO + 14 days	1	1	1		1	1		1		1		1	
OC-2-3a	3	CO + 14 days	1				1	1		1				1	
OC-2-1b	PI	CO + 14 days	1	1	1		1								
OC-2-3b	3	CO + 14 days	1				1								
OC-2-1c	PI	CO + 14 days	1	1	1		1	1		1					
OC-2-3c	3	CO + 14 days	1				1	1		1					
OC-2-OGa	Pre-CDU	CO + 14 days													1
OC-2-OGb	Post-CDU	CO + 14 days													1
OC-3-1a	PI	CO + 21 days					1	1		1					
OC-3-3a	3	CO + 21 days					1	1		1					
OC-3-1b	PI	CO + 21 days					1				1				
OC-3-3b	3	CO + 21 days					1								
OC-3-1c	PI	CO + 21 days					1	1		1					
OC-3-3c	3	CO + 21 days					1	1		1					
OC-3-OGa	Pre-CDU	CO + 21 days													
OC-3-OGb	Post-CDU	CO + 21 days													
OC-4-1a	PI	CO + 28 days	1	1	1		1	1		1		1		1	
OC-4-3a	3	CO + 28 days	1				1	1		1				1	
OC-4-1b	PI	CO + 28 days	1	1	1		1								
OC-4-3b	3	CO + 28 days	1				1			1					
OC-4-1c	PI	CO + 28 days	1	1	1		1	1		1					
OC-4-3c	3	CO + 28 days	1				1	1		1					
OC-4-OGa	Pre-CDU	CO + 28 days													1
OC-4-OGb	Post-CDU	CO + 28 days													1
OC-5-1a	PI	CO + 35 days					1			1					
OC-5-3a	3	CO + 35 days					1			1					
OC-5-1b	PI	CO + 35 days					1				1				
OC-5-3b	3	CO + 35 days					1								

Field Sampling and Analysis Plan - Operation Phase

Condition - Sample ID	Sample Port	Timing	Field Analyses			Laboratory Analyses										Offgas VOCs
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	Remaining CLIN0005					
OC-5-lc	PI	CO + 35 days				1	1	1								
OC-5-3c	3	CO + 35 days				1		1								
OC-5-OGa	Pre-CDU	CO + 35 days														
OC-5-OGb	Post-CDU	CO + 35 days														
OC-6-la	PI	CO + 42 days	1	1	1	1		1		1						
OC-6-3a	3	CO + 42 days	1			1		1								
OC-6-lb	PI	CO + 42 days	1	1	1	1										
OC-6-3b	3	CO + 42 days	1			1	1									
OC-6-lc	PI	CO + 42 days	1	1	1	1		1								
OC-6-3c	3	CO + 42 days	1			1		1								
OC-6-OGa	Pre-CDU	CO + 42 days														1
OC-6-OGb	Post-CDU	CO + 42 days														1
OC-7-la	PI	CO + 49 days				1		1								
OC-7-3a	3	CO + 49 days				1		1								
OC-7-lb	PI	CO + 49 days				1										
OC-7-3b	3	CO + 49 days				1										
OC-7-lc	PI	CO + 49 days				1		1	1							
OC-7-3c	3	CO + 49 days				1		1								
OC-7-OGa	Pre-CDU	CO + 49 days														
OC-7-OGb	Post-CDU	CO + 49 days														
OC-8-la	PI	CO + 56 days	1	1	1	1	1	1		1		1				
OC-8-3a	3	CO + 56 days	1			1		1								1
OC-8-lb	PI	CO + 56 days	1	1	1	1										
OC-8-3b	3	CO + 56 days	1			1										
OC-8-lc	PI	CO + 56 days	1	1	1	1		1								
OC-8-3c	3	CO + 56 days	1			1										
OC-8-OGa	Pre-CDU	CO + 56 days														1
OC-8-OGb	Post-CDU	CO + 56 days														1
TOTAL, Field Operation Phase																
			24	12	12	48	5	32	4	4	6	8				

NOTES:

Four samples from each condition will be required for statistical evaluation of data.

The "a", "b", and "c" sets of samples will be collected consecutively, approximately 1 hour apart.

Fe - Iron

Mn - Manganese

VOCs - Volatile organic compounds

TOC - Total organic carbon

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Condition - Sample ID	Sample Port	Timing	Field Analyses			Laboratory Analyses					
			pH	Fe	Mn	VOCs	VOCs - Q	TOC	TOC-QC	TSS	Remaining CLIN0005
TSS - Total suspended solids											
CO - Completion of optimization phase											
(QC) - Quality control sample											
pH by Method SW9040 (electrometric)											
Fe by Method HACH PAN											
Mn by Method HACH TPTZ											
VOCs by Method 8260B											
TOC by Method E415.2											
TSS by Method E160.2											
Sample Port P1 = Reactor Influent											
Sample Port P1 = Reactor Effluent											
Sample Port Pre-CDU = Prior to Catalytic Destruct Unit (ozone)											
Sample Port Post-CDU = After Catalytic Destruct Unit (ozone)											
Remaining CLIN0005 includes: alkalinity, BOD5, chlorides, COD, ozone, TDS, THM, TIC											

APPENDIX H

Sampling and Analysis Plan, Summary

Sampling and Analysis Plan - Summary

	Field Analyses			Laboratory Analyses							Offgas VOCs	
	pH	Fe	Mn	VOCs	VOCs - QC	TOC	TOC-QC	TSS	Remaining			
									CLIN0005			
Laboratory-Scale Phase												
Conduct baseline analysis	4	4	4	4	1	1	1	1	1			
Develop isotherms				6								
Load catalyst				4	1	1						
Condition 1 (T + 21 days)				4	1	2	1					
Condition 2 (T + 28 days)				4	1	2						
Condition 3 (T + 35 days)				4	1	2	1					
Condition 4 (T + 42 days)				4	1	2						
TOTAL, Laboratory-Scale Phase	4	4	4	30	6	10	3	1	0			
Optimization Phase												
Load catalyst	8	4	4	12	1	8	1	1				
Condition 1 (CM + 7 days)	2	1	1	12	1	6	1	1				2
Condition 2 (CM + 14 days)	2	1	1	12	2	6	1	1				2
Condition 3 (CM + 21 days)	2	1	1	12	1	6		1				2
Condition 4 (CM + 28 days)	2	1	1	12	1	6	1	1				2
Condition 5 (CM + 35 days)	2	1	1	12	1	6		1				2
Condition 6 (CM + 42 days)	2	1	1	12	2	6	1	1				2
TOTAL, Optimization Phase	20	10	10	84	9	44	5	7	0			12
Operation Phase												
Optimum Condition (CO + 07 days)				6		4	1					
Optimum Condition (CO + 14 days)	6	3	3	6	1	4		1	2			2
Optimum Condition (CO + 21 days)				6		4	1					
Optimum Condition (CO + 28 days)	6	3	3	6	1	4		1	2			2
Optimum Condition (CO + 35 days)				6		4	1					
Optimum Condition (CO + 42 days)	6	3	3	6	1	4		1				2
Optimum Condition (CO + 49 days)				6		4	1					
Optimum Condition (CO + 56 days)	6	3	3	6	1	4		1	2			2
TOTAL, Operation Phase	24	12	12	48	5	32	4	4	6			8
TOTAL	48	26	26	162	20	86	12	12	6			20

	Field Analyses			Laboratory Analyses						Offgas
	pH	Fe	Mn	VOCs	VOCs - QC	TOC	TOC-QC	TSS	Remaining CLIN0005	VOCs
NOTES:										
Fe - Iron										
Mn - Manganese										
VOCs - Volatile organic compounds										
TOC - Total organic carbon										
TSS - Total suspended solids										
(QC) - Quality control sample										
pH by Method SW9040 (electrometric)										
Fe by Method HACH PAN										
Mn by Method HACH TPTZ										
VOCs by Method 8260B										
TOC by Method E415.2										
TSS by Method E160.2										
Remaining CLIN0005 includes: alkalinity, BOD5, chlorides, COD, ozone, TDS, THM, TIC										
T - Receipt of drummed groundwater										
CM - Completion of mobilization										
CO - Completion of optimization phase										

APPENDIX I

Technical Memorandum

TECHNICAL MEMORANDUM

To: Kevin Wong, McClellan EM

Date: July 29, 1998

From: Marcus Taylor, URS Greiner

Subject: Practical Quantitation Limits for Groundwater Analyses

This technical memorandum documents the challenges encountered by URS Greiner (URSG) in meeting the requirements that McClellan EM staff and the Central Valley Regional Water Quality Board (CVRWCB) have for practical quantitation limits (PQLs) for the analysis of groundwater under the fixed price PRDA contract.

In the July 21, 1998 meeting at McClellan AFB to clarify comments on the Draft Final Work Implementation Plan (WIP), Mr. Kevin Wong the QAE for the PRDA demonstration requested that a technical memorandum be included as part of the Final WIP detailing the challenges with meeting the PQLs for the analysis of groundwater.

On December 15, 1997 McClellan AFB issued a contract F04699-98-C-0081 under the PRDA to URSG to demonstrate catalytic ozonation of groundwater. Section 4.13 of the Performance Work Statement (PWS) mandates that the analytical capabilities of the laboratory shall be sufficient for the methods specified in the SAP and the McClellan RI/FS QAPP. The QAPP mandates a PQL of 1.0 µg/L for samples analyzed in accordance with Method 8260A. URSG had prepared a budget that reflected the PQLs required in the QAPP, and prepared the working copy of the Work Implementation Plan (WIP). At that time it was URSG's understanding that the ECOCHOICE (EC) system would be evaluated for its potential to meet the Waste Discharge Requirements (WDRs) contained in the discharge permit issued by Sacramento County. The WDRs are expressed in units of mg/L.

As part of comments received on the Draft WIP, Mr. Mark Malinowski of CVRWQCB indicated in his letter of April 7, 1998 that if the Method Detection Limits (MDLs) found in the QAPP were used that they will not be sufficient to determine if the treatment process is capable of meeting NPDES effluent limitations. Those limitations specify that the concentration for VOCs must be below 0.5 µg/L using the EPA 8260A analytical method. URSG personnel contacted Mr. Tim Chapman of TRW for clarification. Mr. Chapman indicated that although the PWS required a PQL of 1.0 µg/L that the sample analysis should be in accordance with the requirements of the CVRWQCB.

URSG then contacted a number of laboratories regarding the PQL requirement of 0.5 µg/L. The responses were unanimous in that they indicated that under EPA Method 8260A that a PQL of 0.5 µg/L could not be achieved for the target list. MDLs are developed based on a statistical analysis of results generated by a laboratory performing the method in question. PQLs are reporting limits that a laboratory feels that it can report with confidence. The laboratory personnel indicated that typically there is a multiplier of one-half to one order of magnitude between the MDL and the PQL. This multiplier varies depending upon the specific constituent. This multiplier is essentially a factor of safety between the results of the statistical analysis and what the laboratory can report. Decreasing the PQL requires the laboratory to report values in which they have less confidence.

URSG then contacted OHM, who was charged with operating the GWTP in accordance with the requirement of the CVRWQCB. OHM provided a list of PQLs that varied between 0.5 µg/L and 1.0 µg/L. Specific constituents with PQLs of 1.0 µg/L included Freon 11, Freon 12, and Freon 113, as well as chloromethane and bromomethane (Table 5-2 of the Final Quality Assurance Project Plan). These new PQLs were presented in the Draft Final WIP

During the review of the Draft Final WIP, Mr. Chapman indicated his preference that the Final WIP indicate that the EC system discharge would be evaluated for conformance with the WDRs contained in the discharge permit issued by Sacramento County. URSG was concerned by this directive and recontacted Mr. Malinowski by telephone to discuss how the potential change to the WIP might not be in conformance with the requirements of the CVRWQCB. During the conversation with Mr. Malinowski, URSG asked the question as to why $\mu\text{g/L}$ levels were required to verify compliance with WDRs expressed in mg/L . Mr. Malinowski indicated that there was a separate permit that had been issued to McClellan AFB for the GWTP in 1986 and that although "McClellan AFB did not recognize the permit" that it has been reissued from 1986 to the present time. URSG then raised the issue regarding the universal response from laboratories indicating that a PQL of $1.0 \mu\text{g/L}$ was not achievable for all constituents on the target list. Mr. Malinowski asked about what specific constituents were not able to be quantified to the level, and then indicated that he was aware of the limitations.

Since the beginning of the project, EPA Method 8260A has been updated and renamed to EPA Method 8260B. URSG will be using EPA Method 8260B. After canvassing a number of analytical laboratories URSG has verified that Curtis and Tompkins serving as the primary laboratory and APPL, Inc. serving as the secondary laboratory can meet the calibration requirements of the Basewide QAPP, and that where possible they will report a PQL of $0.5 \mu\text{g/L}$. In negotiating with the laboratories URSG can provide these lower PQLs at no additional cost to McClellan AFB.

APPENDIX J

**Determination of Total Organic Carbon in Aqueous
Samples Using OI 700 TOC Instrument**

APPENDIX J

DETERMINATION OF TOTAL ORGANIC AND INORGANIC CARBON IN USING the OI TOC APPARATUS

Scope: This method covers the measurement of organic and inorganic carbon in drinking, surface and saline waters, domestic and industrial wastes using the OI TOC instrument which performs the persulfate-Ultraviolet Oxidation method. This SOP describes the preparation of aqueous samples for total organic carbon (TOC), and total inorganic carbon (TIC) analysis. Quantitation of TOC is calculated by subtracting the inorganic carbon from the total carbon.

TOC is determined after the sample has been purged of TIC, by the measurement of CO₂ released by oxidation of the organic carbon by persulfate in the presence of ultraviolet light. The CO₂ produced is sparged continuously from solution and is carried in the gas stream to an infrared analyzer which is specifically tuned to the absorptive wavelength of CO₂. The instruments' microprocessor calculates the area of the peaks produced by the analyzer, compares them to the peak area of the calibration standard stored in its' memory, and prints out an organic carbon value in milligrams per liter. TIC is determined by the measurement of carbon dioxide released by acidification of the sample with phosphoric acid which converts carbonate and bicarbonate ions into dissolved CO₂. This CO₂ is purged from the solution, and measured by non-dispersive infrared analyzer (NDIR) as described above.

NOTE for Solids Determination: This method really only works for waters. TOC on solids is generally and ill advised determination horrendously prone to errors. However clients have insisted, and we have done TOC determinations on solids, often referred to as "mud shakes". Samples that contain solids must be centrifuged or allowed to settle. Analysis is performed only on the supernatant solution. If a client requires that the solids be included, they must be reduced to a size that will fit through the syringe needle. The size reduction may be accomplished by manual agitation or blender mixing.

REFERENCES: EPA 415.2; EPA 9060; ASTM D2579; SMWW 18:5310 C; AOAC 14:33.044; and Total Organic Carbon Analyzer Users Manual for OI Analytical Model 700.

Sample Size Requirement: Full VOA vial (approximately 40 to 50mls)

Sample preservation: Sample is acidified to a pH less than 2 with sulfuric acid.

QUALITY CONTROL:

1. The OI TOC apparatus is calibrated using the instrument manufacturers specifications (see manual). This includes taking the average millivolt reading from 5 to 7 replicates of a 25 ppm standard. If the reading is outside 450 mv to 550 mv, corrective action needs to be performed. Check standard preparation and instrument maintenance. If the reading is within 450 to 550 mv, set the instrument to read 25 ppm at the average mv reading from the replicate standards.
2. Calibration verification includes analyzing 5 mg/L, 25 mg/L and 45 mg/L standards using the following acceptance criteria: 5 mg/L and 45 mg/L standards must be within 80-120% of the true value; 25 mg/L must be with 90-110% of the true value. If any of these standards do not meet criteria, the instrument needs to be recalibrated.
3. A 25 mg/L second source standard must be run at the beginning of each run (ICV), after every 10 sample runs (CCV), and at the end of the run (CCV). Recovery must be in the range of 90 - 110 percent.
4. A batch of samples is limited to 20 samples, analyzed on the same day, and must include the following QC samples:

Sample	Limits
Method blank	< 1 ppm
Laboratory control standard	85 - 115%
Matrix spike- Water	80 - 120%
Matrix Spike-Soil	65-135%
Duplicates (either MS/MSD or sample/sample duplicate	15 %RPD
ICV/CCV	90-110%

SAMPLE PRESERVATION: Preserve with H₂SO₄ to pH <2. Store in glass containers at 4 C and protect from sunlight and oxygen.

LIMS PRODUCT: TOC

APPARATUS: Model 700 Total Organic Carbon Analyzer from OI Analytical.

REAGENTS:

1. Sodium Persulfate (100g/L) - Add 100 grams of Na₂S₂O₈ to 1000 mL volumetric flask, dilute to volume with reagent water. Do not Heat. Filter through glass microfiber filter.
2. Phosphoric Acid - Prepare a 5 % by volume solution of phosphoric acid by adding 59 mLs of ACS reagent grade 85% H₃PO₄ to 1000 mL volumetric flask and bring to volume with reagent grade water.
3. TOC Stock Standard - Prepare a stock solution by adding 2.128 grams of dry KHP (potassium biphthalate) to a 1000 mL volumetric flask and dilute to volume with reagent grade water. This is 1000 mg/L TOC.
4. TIC Stock Standard - Prepare a stock solution by adding 8.826 grams of dry Na₂CO₃ (sodium carbonate) to a 1000 mL volumetric flask and dilute to volume with reagent grade water. This contains 1000 mg/L TIC.
5. Nitrogen Gas - 99.9*% purity - service pressure 30 psi.

PROCEDURE: RUNNING THE OI 700 TOC Analyzer.

1. Turn on nitrogen gas flow and confirm 30 psi delivery pressure.
2. Confirm that reagent bottles are being purged and are full.
3. Turn on power using the main POWER switch and press down on the #1 key. The following message will appear: TIC/TOC ANALYSIS STANDBY
4. Confirm that purge and carrier gas flows are set for 6.0 purge and 5.0 carrier.
5. When display screen reads READY water blanks can now be run to clean the instrument.
6. Instrument clean out:
 - a. Clean the instrument by inserting the sampling tube into a 1L beaker filled with reagent grade water. (Milli-Q)
 - b. Install 10 ppm sample loop and make sure volume is set to 10.00 by pressing SET SAMPLE volume key, enter volume and press ENTER.

- 1 c. Press the RUN/STOP key to begin the clean out sequence. Run at least 10 blanks.
- 2 7. Run calibration verification standards at 5, 25 and 45 mg/L. See QC section for acceptance
- 3 criteria.

4 RUNNING SAMPLES

- 5 1. Confirm that the SAMPLE PUMP, SAMPLE LOOP and AUTO-RUN options are enabled by
- 6 pressing SET SYSTEM CONFIGURATION key and review the screen displays. Enable by
- 7 pressing 1 ENTER, disable by pressing 0 ENTER.
- 8 2. Make sure appropriate sample loop is installed and loop volume is correct in processor mem-
- 9 ory by pressing SET SAMPLE VOLUME key and entering the value marked on the loop and
- 10 pressing ENTER.
- 11 3. Press the RUN/STOP key to begin analysis. Place the sampling tube in each sample as re-
- 12 quired.
- 13 3. Near the end of 3 minutes the millivolt response of the TIC will be printed. Report ppm on
- 14 far right of printout. Note: after 1.10 minutes sample tube may be put to the next sample.
- 15 4. Near the end of 8 minutes the TOC values will be printed. Report the ppm value on the far
- 16 right of the page.
- 17 5. Samples are out of range above 45 ppm and must be diluted and rerun. Reported runs for
- 18 these samples should have instrument readings in the 10 to 45 ppm range.
- 19 6. Samples which appear "dirty" should be diluted prior to analysis to prevent overloading the
- 20 instrument resulting in carryover and instrument down time. Final results for these samples
- 21 should also have instrument measurements in the 10 to 45 ppm range.

22 SOIL SAMPLE PREPARATION

- 23 1. Weigh 25 grams of sample and place in clean glass blender. Record sample weight.
- 24 2. Measure 250 mL of deionized water. Rinse the weigh boat with the water and combine in the
- 25 blender.
- 26 3. Gently start the blender and run on low or pulse until sample is blended.
- 27 4. Blend for 5 minutes.
- 28 5. Immediately pour aliquot and introduce it into the TOC instrument as for water.
- 29 1. Quality control requirements include a method blank, matrix QC (sample, spike and spike
- 30 duplicate) and an LCS (or blank spike) prepared in the same manner as the samples.
- 31 7. Although specified in SW-846, water and soil samples are usually only analyzed ONE time.
- 32 This method modification is documented on our laboratory reports. All samples associated
- 33 with the Navy, AFCEE, Army Corps of Engineers and State of Utah MUST be analyzed in
- 34 quadruplicate unless project specific requirements state otherwise.

1 INSTRUMENT MAINTENANCE

2 A log book for the instrument should be kept in accordance with C&T instrument logbook SOP. (QA
3 SOPS filename benchbk.wpd). The logbook should at a minimum document the instrument operation and
4 periodic maintenance, record results of inspections, and component replacement.

5 Refer to the Total Organic Carbon Analyzer User's Manual for procedures to calibrate the instrument,
6 troubleshoot problems, and replace worn or damaged parts. Maintenance is in Chapter 5. Preventative
7 maintenance schedule is as follows:

8	Maintenance Item	Interval/Schedule
9	Reagent Reservoirs	25-2,500 injections
10	Injection Port septum	50-200 Injections
11	Tube end fitting connections	100 hours
12	IR Zero	100 hours
13	Gas Service	100 hours
14	Six Port Valves	200-2000 hours
15	Sample Pump	2000 hours
16	Activated carbon scrubber	2000 hours
17	Digestion vessel, condensation chamber	2000 hours
18	Permeation Tube	2000 hours
19	IR Cell	2000-4000 hours
20	IR Linearization	User Determined

21 See Chapter 5, pages 95-119 of the OI Model 700 users guide for details and instructions on how to per-
22 form each of the above operations.

APPENDIX K

MSDS for Oxygen

MSDS DATE: 1/17/75
CHANGE NO.: 13044

Per Assistant, Contact:
Regulatory Affairs Dept.
PO Box 967 Ames, IA 50010
(505) 227-4224

HACH COMPANY
PO BOX 967
AMES, IA 50010

Emergency Telephone to
Rocky Mountain Poison Ctr.
(303) 525-5716

I. PRODUCT IDENTIFICATION

PRODUCT NAME: PPM Indicator Solution 0.1%
CAS NO.: NA CHEMICAL NAME: Not applicable
FORMULA: Not applicable CHEMICAL FAMILY: Not applicable
MSDS NUMBER: H00288

II. INGREDIENTS

Diamethylformamide
PCY: CHS CAS NO.: 68-12-2 SARA: LISTED
TLV: 10 ppm (skin) PEL: 10 ppm (skin)
HAZARD: Toxic. Severe eye irritant. May cause embryotoxicity, cancer

Ammonium Acetate
PCY: CHS CAS NO.: 631-91-8 SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: Moderately toxic; may cause irritation

Octyldecylpolyethoxysilane
PCY: CHS CAS NO.: 9636-19-5 SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: May cause irritation

1-(2-Pyridylamino)-2-naphthol
PCY: CI CAS NO.: 85-05-8 SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: Toxicity unknown; may cause irritation

Demineralized Water
PCY: to 100 CAS NO.: 7732-18-5 SARA: NOT LISTED
TLV: Not applicable PEL: Not applicable
HAZARD: None

III. PHYSICAL DATA

STATE: liquid APPEARANCE: Clear, orange-red ODOR: Ammonia
SOLUBILITY IN: WATER: Miscible ACID: None OTHER: Not determined
BOILING POINT: 101°C MELTING PT.: NA SPEC GRAVITY: 1.044 PH: 8.8
VAPOR PRESSURE: Not determined VAPOR DENSITY (air=1): NA
EVAPORATION RATE: 0.25 METAL CORROSIVITY - ALUMINUM: NO STEEL: NO
STABILITY: Stable
STORAGE PRECAUTIONS: Store separate from metals.

IV. FIRE, EXPLOSION HAZARD AND REACTIVITY DATA

FLASH PT.: >15°C; >280°F METHOD: closed cup
FLAMMABILITY LIMITS - LOWER: NO UPPER: NO
SUSCEPTIBILITY TO SPONTANEOUS HEATING: None
SHOCK SENSITIVITY: None AUTOIGNITION PT.: NO
EXTINGUISHING MEDIA: water or dry chemical
FIRE/EXPLOSION HAZARD: May emit toxic fumes of diethylaniline, nitrogen oxides and carbon monoxide
HAZARDOUS RECOMP. PRODUCTS: May emit toxic fumes of diethylaniline, carbon monoxide and nitrogen oxides in fire
OXIDIZER: No MFPA Codes: Health: 1 Flammability: 1 Reactivity: 1
CONDITIONS TO AVOID: Heat, flames; contact with oxidizers, halogenated hydrocarbons, inorganic nitrates, metals, carbon tetrachloride

V. HEALTH HAZARD DATA

THIS PRODUCT MAY BE: irritating to eyes, skin and respiratory tract.
ACUTE TOXICITY: Not determined
ROUTES OF EXPOSURE: ingestion, inhalation, skin absorption
TARGET ORGANS: liver, kidneys, fetus
CHRONIC TOXICITY: Not determined
ROUTES OF EXPOSURE: ingestion, inhalation, skin absorption
TARGET ORGANS: liver, kidneys, fetus
CANCER INFORMATION: An ingredient of this mixture is an experimental carcinogen, mutagen and teratogen.
ROUTES OF EXPOSURE: Not determined
TARGET ORGANS: Not determined
OVEREXPOSURE: Causes eye irritation. May cause abdominal pain, skin & respiratory irritation, nausea, vomiting, constipation, diarrhea, facial flushing (especially after drinking alcohol), liver and kidney injury, increased blood pressure. May be embryotoxic.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing eye, skin and respiratory tract irritation.

VI. PRECAUTIONARY MEASURES

Avoid contact with eyes, skin and clothing
Do not breathe vapor.
Wash thoroughly after handling.
PROTECTIVE EQUIPMENT: fume hood, lab grade goggles, supported respirator, other diamethylformamide-resistant gloves, lab coat

VII. FIRST AID

EYE AND SKIN CONTACT: Immediately flush eyes and skin with water for 15 minutes. Remove contaminated clothing. Call physician.
INGESTION: Give a slurry of powdered activated charcoal. Induce vomiting. Stickling finger down throat. Never give anything by mouth to an unconscious person. Call physician.
INHALATION: Remove to fresh air. Give artificial respiration if necessary. Call physician.

VIII. SPILL AND DISPOSAL PROCEDURES

IN CASE OF SPILL OR RELEASE: Dissolve or mix the material with a common solvent. Burn in an EPA approved hazardous waste incinerator.
DISPOSE OF IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REGULATIONS.

IX. TRANSPORTATION DATA

D.O.T. PROPER SHIPPING NAME: Not Currently Regulated
HAZARD CLASS: NA ID: NA GROUP: NA

I.C.A.S. PROPER SHIPPING NAME: Not Currently Regulated
HAZARD CLASS: NA ID: NA GROUP: NA

I.M.C. PROPER SHIPPING NAME: Not Currently Regulated
HAZARD CLASS: NA ID: NA GROUP: NA

X. REFERENCES

- 1) TLV's Threshold Limit Values and Biological Exposure Indices for 1970. American Conference of Governmental Industrial Hygienists. 1970.
- 2) Air Contaminants, Federal Register, Vol. 54, No. 12, Thursday, June 15, 1989, pp. 2382-2383.
- 3) In-house information
- 4) Technical judgment

SPECIAL NOTE: In laboratory tests, application of HMF to the skin of pregnant rats caused fetal deaths when the dosages were close to the lethal dose level for the mother. Avoid inhalation and contact with.

SARA: This product contains a chemical or chemicals subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

PER CALIFORNIA PROPOSITION 65: "WARNING - This product contains a chemical known to the State of California to cause cancer, birth defects or it reproductive harm."

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE ACCURATE. HOWEVER, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF.

(C) HACH CO. 19

MSDS DATE: 1/01/95
CHANGE NO.: 15301

For Assistance, Contact:
Regulatory Affairs Dept.
PO Box 907 Ames, IA 50010
(800) 227-4224

HACH COMPANY
PO BOX 907
AMES, IA 50010

HACH ORDERS: 975383

Emergency Telephone 8
Rocky Mountain Poison Ctr.
(800) 625-5711

I. PRODUCT IDENTIFICATION

PRODUCT NAME: TPTZ Iron Supplement Powder Pillars
CAS NO.: NA CHEMICAL NAME: Not applicable
FORMULA: Not applicable CHEMICAL FAMILY: Not applicable
MSDS NUMBER: M03114

II. INGREDIENTS

Sodium Hydroxide
PCT: C20 CAS NO.: 7775-14-6 SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: Flammable solid; cause moderate eye irritation; allergen

Sodium Metabisulfite
PCT: C21 CAS NO.: 7481-57-4 SARA: NOT LISTED
TLV: 5 mg/m³ PEL: 5 mg/m³
IARC: LISTED
HAZARD: May cause irritation; allergen; moderately toxic

Sodium Thiosulfate, Anhydrous
PCT: C45 CAS NO.: 7772-98-7 SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: May cause irritation

Citric Acid Monosodium Salt, Anhydrous
PCT: C25 CAS NO.: 10044-35-5 SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: May cause irritation

TPTZ Tri-p-Toluenesulfonate
PCT: C2 CAS NO.: None SARA: NOT LISTED
TLV: Not established PEL: Not established
HAZARD: May cause irritation; toxic properties unknown

III. PHYSICAL DATA

STATE: solid APPEARANCE: White powder SMELL: Sulfur
SOLUBILITY IN: WATER: Completely soluble ACID: Not determined
OTHER: Not determined BOILING POINT: NA MELTING PT.: NA
SPEC GRAVITY: NA pH: of 1% soln. = 3.0 VAPOR PRESSURE: Not applicable
VAPOR DENSITY (air=1): NA EVAPORATION RATE: NA
METAL CORROSIVITY - ALUMINUM: 0.007 in/yr STEEL: 0.162 in/yr
STABILITY: Stable
STORAGE PRECAUTIONS: Store in a cool, dry place.

IV. FIRE, EXPLOSION HAZARD AND REACTIVITY DATA

FLASH PT.: Not applicable METHOD: NA
FLAMMABILITY LIMITS - LOWER: NA UPPER: NA
SUSCEPTIBILITY TO SPONTANEOUS HEATING: In contact with water and air.
SHOCK SENSITIVITY: None AUTOIGNITION PT.: NA
EXTINGUISHING MEDIA: dry chemical, alcohol foam or carbon dioxide
FIRE/EXPLOSION HAZARDS: Heats spontaneously in contact with water; reacts with oxidizers
HAZARDOUS REACTION PRODUCTS: Toxic SO₂ fumes in fire; corrosive fumes in contact with water or acid
OXIDIZER: No NFPA Codes: Health: 2 Flammability: 1 Reactivity: 1
CONDITIONS TO AVOID: Excess moisture, acids, oxidizers, heat, flames

V. HEALTH HAZARD DATA

THIS PRODUCT MAY BE: Irritating to eyes, skin, respiratory tract, and may cause allergic respiratory tract reaction.

ACUTE TOXICITY: Not determined

ROUTES OF EXPOSURE: Ingestion, inhalation

TARGET ORGANS: Not determined

CHRONIC TOXICITY: Not determined

ROUTES OF EXPOSURE: Not determined

TARGET ORGANS: Not determined

CANCER INFORMATION: Not determined

ROUTES OF EXPOSURE: Not determined

TARGET ORGANS: Not determined

OVEREXPOSURE: Causes eye and respiratory irritation. May cause skin irritation; may cause allergic respiratory reaction. Ingestion may cause GI irritation, coughing, difficulty in breathing, stomach pain, vomiting, diarrhea, CNS and circulatory effects.

HEALTH CONDITIONS AGGRAVATED BY EXPOSURE: Respiratory conditions such as asthma

VI. PRECAUTIONARY MEASURES

Avoid contact with eyes and skin.
Do not breathe dust.
Wash thoroughly after handling.
Protect from moisture
Keep away from acids.
PROTECTIVE EQUIPMENT: adequate ventilation. Lab grade gloves, disposable latex gloves

VII. FIRST AID

EYE AND SKIN CONTACT: Immediately flush eyes with water for 15 minutes; physician. Wash skin with soap and plenty of water.
INGESTION: Do NOT induce vomiting. Give 1 - 2 glasses of water. Call a physician immediately. Never give anything by mouth to an unconscious person.
INHALATION: Remove to fresh air. Give artificial respiration if needed. Call physician.

VIII. SPILL AND DISPOSAL PROCEDURES

IN CASE OF SPILL OR RELEASE: Sweep spilled material into a bucket and dissolve with water. Neutralize to a pH between 6 and 9 with an alkali such as soda ash. Flush neutralized waste to the drain with an excess of water.

DISPOSE OF IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REGULATIONS.

IX. TRANSPORTATION DATA

D.O.T. PROPER SHIPPING NAME: Not Currently Regulated
HAZARD CLASS: NA ID: NA GROUP: NA

I.C.A.D. PROPER SHIPPING NAME: Not Currently Regulated
HAZARD CLASS: NA ID: NA GROUP: NA

I.N.O. PROPER SHIPPING NAME: Not Currently Regulated
HAZARD CLASS: NA ID: NA GROUP: NA

X. REFERENCES

- 1) TLV's Threshold Limit Values and Biological Exposure Indices - 1989. American Conference of Governmental Industrial Hygienists.
- 2) Air Contaminants, Federal Register, Vol. 54, No. 12, Thursday, Jan. 17, 1989, pp. 2332-2383.
- 3) In-house information
- 4) Fire Protection Guide to Hazardous Materials, 10th Ed., Quincy, MA: National Fire Protection Association, 1991.
- 5) Technical Judgment
- 6) Outside testing.
- 7) Macculin, R.E. et al. Clinical Toxicology of Commercial Products, 3rd Ed. Baltimore: The Williams and Wilkins Co., 1984.

SPECIAL NOTE: Sulfites are strong sensitizers. Inhalation and ingestion may cause allergic respiratory reactions in asthmatics. Persons with respiratory conditions should take special care when working with products that contain sulfites. TPTZ Tri-p-Toluenesulfonate is used on Low Volume Exemption for determination of iron in water.

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE ACCURATE. HOWEVER, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF.

Hach Company, WORLD HEADQUARTERS, PO Box 300, Loveland, CO 80539

Hach Europe, BP 229, 85000 Norder 1, BELGIUM

(C) HACH CO. 1995

PAGE 1 OF

BOC GASES**MATERIAL SAFETY DATA SHEET****PRODUCT NAME: OXYGEN****1. Chemical Product and Company Identification**

BOC Gases,
A Division of
The BOC Group, Inc
575 Mountain Avenue
Murray Hill, NJ 07974

BOC Gases,
A Division of
BOC Canada Ltd.
89 Queensway West
Mississauga, Ontario L5B 2V2

TELEPHONE NUMBER: (908)464-8100
24-HOUR EMERGENCY TELEPHONE NUMBER:
CHEMTREC (800)424-9300

TELEPHONE NUMBER: (905)273-7700
24-HOUR EMERGENCY TELEPHONE NUMBER:
(905)949-3777
EMERGENCY RESPONSE PLAN NO: 20101

PRODUCT NAME: OXYGEN
CHEMICAL NAME: Oxygen
COMMON NAMES/SYNONYMS: None
TDG CLASSIFICATION: 2.2 (5.1)
WHMIS CLASSIFICATION: A, C

PREPARED BY: Loss Control (908)464-8100/(905)273-7700
PREPARATION DATE: 12/17/96
REVIEW DATES: 12/17/96
LATEST REVISION DATE: 12/17/96
PREVIOUS REVISION DATE: None

2. Composition, Information on Ingredients

INGREDIENT	% VOLUME	PEL-OSHA ¹	TLV-ACGIH ²	LD ₅₀ or OC ₅₀ Route/Species
Oxygen FORMULA: O ₂ CAS: 7782-44-7 RTECS #: RS2060000	99.6 to 100.0	Not Available	Not Available	Not Available

¹ As stated in 29 CFR 1910, Subpart Z (revised July 1, 1993)

² As stated in the ACGIH 1994-95 Threshold Limit Values for Chemical Substances and Physical Agents

3. Hazards Identification

EMERGENCY OVERVIEW
Elevated oxygen levels may result in cough and other pulmonary changes. High concentrations of oxygen (greater than 75%) causes symptoms of hyperoxia which included cramps, nausea, dizziness, hypothermia, anisocoria, respiration difficulties, bradycardia, fainting spells and convulsions capable of leading to death. Nonflammable. Oxidizer will accelerate combustion.

PRODUCT NAME: OXYGEN

ROUTE OF ENTRY:

Skin Contact No	Skin Absorption No	Eye Contact No	Inhalation Yes	Ingestion No
--------------------	-----------------------	-------------------	-------------------	-----------------

HEALTH EFFECTS:

Exposure Limits No	Irritant No	Sensitization No
Teratogen No	Reproductive Hazard No	Mutagen Yes
Synergistic Effects None known		

Carcinogenicity: -- NTP: No IARC: No OSHA: No

EYE EFFECTS:

Contact with liquid product may cause tissue freezing.

SKIN EFFECTS:

Contact with liquid product may cause tissue freezing.

INGESTION EFFECTS:

Contact with liquid product may cause tissue freezing.

INHALATION EFFECTS:

High concentrations of oxygen (greater than 75%) causes symptoms of hyperoxia which included cramps, nausea, dizziness, hypothermia, ambylopia, respiration difficulties, bradycardia, fainting spells and convulsions capable of leading to death. The property is that of hyperoxia which leads to pneumonia. Concentrations between 25 and 75% present a risk of inflammation of organic matter in the body.

Oxygen concentrations between 20 to 95% have produced genetic changes in mammalian cell assay test systems.

NFPA HAZARD CODES

Health: 0
Flammability: 0
Reactivity: 0

HIMIS HAZARD CODES

Health: 0
Flammability: 0
Reactivity: 0

RATINGS SYSTEM

0 = No Hazard
1 = Slight Hazard
2 = Moderate Hazard
3 = Serious Hazard
4 = Severe Hazard

4. First Aid Measures
EYES:

Never introduce ointment or oil into the eyes without medical advice! In case of freezing or cryogenic "burns" caused by rapidly evaporating liquid, DO NOT WASH THE EYES WITH HOT OR EVEN TEpid WATER! Remove victim from the source of contamination. Open eyelids wide to allow liquid to evaporate. If pain is present, refer the victim to an ophthalmologist for treatment and follow up. If the victim cannot tolerate light, protect the eyes with a light bandage.

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SKIN:

For dermal contact or frostbite: Remove contaminated clothing and flush affected areas with lukewarm water. **DO NOT USE HOT WATER.** A physician should see the patient promptly if the cryogenic "burn" has resulted in blistering of the dermal surface or deep tissue freezing.

INGESTION:

A physician should see the patient promptly if the cryogenic "burn" has resulted in blistering of the dermal surface or deep tissue freezing.

INHALATION:

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO OXYGEN. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS. Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Further treatment should be symptomatic and supportive. Inform the treating physician that the patient could be experiencing hyperoxia.

5. Fire Fighting Measures

Conditions of Flammability: Not flammable, Oxidizer		
Flash point: None	Method: Not Applicable	Autoignition Temperature: None
LEL(%): None		UEL(%): none
Hazardous combustion products: None		
Sensitivity to mechanical shock: None		
Sensitivity to static discharge: None		

FIRE AND EXPLOSION HAZARDS:

High oxygen concentrations vigorously accelerate combustion.

EXTINGUISHING MEDIA:

Water spray to keep cylinders cool. Extinguishing agent appropriate for the combustible material.

FIRE FIGHTING INSTRUCTIONS:

If possible, stop the flow of oxygen which is supporting the fire.

6. Accidental Release Measures

Evacuate all personnel from affected area. Use appropriate protective equipment. If leak is in user's equipment, be certain to purge piping with inert gas prior to attempting repairs. If leak is in container or container valve, contact the appropriate emergency telephone number listed in Section 1 or call your closest BOC location.

7. Handling and Storage

Electrical classification:

Nonhazardous

Dry product is noncorrosive and may be used with all materials of construction. Moisture causes metal oxides which are formed with air to be hydrated so that they include volume and lose their protective role (rust formation). Concentrations of SO_2 , Cl_2 , salt, etc. in the moisture enhances the rusting of metals in air.

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Carbon steels and low alloy steels are acceptable for use at lower pressures.

For high pressure applications stainless steels are acceptable as are copper and its alloys, nickel and its alloys, brass bronze, silicon alloys, Monel (R), Inconel (R) and beryllium. Lead and silver or lead tin alloys are good gasket materials. Teflon (R), Teflon (R) composites, or Kel-F (R) are preferred non-metallic gasket materials.

Check with the supplier to verify oxygen compatibility for the service conditions.

Oxygen should not be used as a substitute for compressed air in pneumatic equipment since this type generally contains flammable lubricants.

Stationary customer site vessels should operate in accordance with the manufacturer's and BOC's instruction. Do not attempt to repair, adjust or in any other way modify the operation of these vessels. If there is a malfunction or other type of operations problem with the vessel, contact the closest BOC location immediately.

Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the system.

Protect cylinders from physical damage. Store in cool, dry, well-ventilated area away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 130°F (54°C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders being stored for excessive periods of time. Post "NO SMOKING OR OPEN FLAMES" signs in the storage area or use area. There should be no sources of ignition in the storage or use area.

For additional storage recommendations, consult Compressed Gas Association's Pamphlets P-1, P-14 and Safety Bulletin SB-2.

Never carry a compressed gas cylinder or a container of a gas in cryogenic liquid form in an enclosed space such as a car trunk, van or station wagon. A leak can result in a fire, explosion, asphyxiation or a toxic exposure.

8. Exposure Controls, Personal Protection

EXPOSURE LIMITS:

INGREDIENT	% VOLUME	PEL-OSHA ¹	TLV-ACGIH ²	LD ₅₀ or OC ₅₀ Route/Species
Oxygen FORMULA: O ₂ CAS: 7782-44-7 RTECS #: RS2060000	99.6 to 100.0	Not Available	Not Available	Not Available

Refer to individual state or provincial regulations, as applicable, for limits which may be more stringent than those listed here.

ENGINEERING CONTROLS:

Use local exhaust to prevent accumulation of high concentrations that increase the oxygen level in air to more than 25%.

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PRODUCT NAME: OXYGEN
EYE/FACE PROTECTION:

Safety goggles or glasses as appropriate for the job. Faceshield is recommended for cryogenic liquids.

SKIN PROTECTION:

Protective gloves made of any suitable material appropriate for the job. Insulated gloves recommended for cryogenic liquids.

OTHER/GENERAL PROTECTION:

Safety shoes, safety shower.

9. Physical and Chemical Properties

PARAMETER	VALUE	UNITS
Physical state (gas, liquid, solid)	: Gas	
Vapor pressure	: Above critical temp.	
Vapor density Air=1)	: 1.11	
Evaporation point	: Not Available	
Boiling point	: -297.3	°F
	: -182.9	°C
Freezing point	: -361.8	°F
	: -218.8	°C
pH	: Not Applicable	
Specific gravity at STP	: Not Available	
Oil/water partition coefficient	: Not Available	
Solubility (H ₂ O)	: Slightly soluble	
Odor threshold	: Not Applicable	
Odor and appearance	: Colorless, odorless gas	

10. Stability and Reactivity
STABILITY:

Stable.

INCOMPATIBLE MATERIALS:

All flammable materials.

HAZARDOUS DECOMPOSITION PRODUCTS:

None.

HAZARDOUS POLYMERIZATION:

Will not occur.

PRODUCT NAME: OXYGEN**11. Toxicological Information****MUTAGENIC:**

Oxygen concentrations between 20 to 95% have produced genetic changes in mammalian cell assay test systems.

12. Ecological Information

No data given.

13. Disposal Considerations

Do not attempt to dispose of residual waste or unused quantities. Return in the shipping container PROPERLY LABELED, WITH ANY VALVE OUTLET PLUGS OR CAPS SECURED AND VALVE PROTECTION CAP IN PLACE to BOC Gases or authorized distributor for proper disposal.

14. Transport Information

PARAMETER	US DOT	CTDG
PROPER SHIPPING NAME:	Oxygen, compressed	Oxygen, compressed
HAZARD CLASS:	2.2	2.2 (5.1)
IDENTIFICATION NUMBER:	UN 1072	UN 1072
SHIPPING LABEL:	NONFLAMMABLE GAS, OXIDIZER	NONFLAMMABLE GAS, OXIDIZER

15. Regulatory Information**SARA TITLE III NOTIFICATIONS AND INFORMATION****SARA TITLE III - HAZARD CLASSES:**

Fire Hazard

Sudden Release of Pressure Hazard

16. Other Information

Compressed gas cylinders shall not be refilled without the express written permission of the owner. Shipment of a compressed gas cylinder which has not been filled by the owner or with his/her (written) consent is a violation of transportation regulations.

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES:

Although reasonable care has been taken in the preparation of this document, we extend no warranties and make no representations as to the accuracy or completeness of the information contained herein, and assume no responsibility regarding the suitability of this information for the user's intended purposes or for the consequences of its use. Each individual should make a determination as to the suitability of the information for their particular purpose(s).

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APPENDIX L

Site Specific Spill Plan

SITE SPECIFIC SPILL PLAN **DATE: 5/14/1998** **FACILITY NO: IC 31****SITE DESCRIPTION:** Site IC 31 Innovative Technology Treatment Pad**ON-BASE SPILL DISCOVERY AND NOTIFICATION PROCEDURES****REPORT SPILL OR POTENTIAL RELEASE OF:**

- Any quantity of an extremely hazardous substance (EHS)
- 1 lb/ 1pint or more of a hazardous substance.
- Any quantity if fire or health hazard is present.
- Any quantity of mercury.
- Any quantity from a pressurized system.
- Bulging or Abandoned Drums (DANGER -Don't Touch!)

ACTIONS TO TAKE:

- Alert Personnel - Evacuate if necessary.
- Information to report to Fire Dept.:
 - Your name and phone number
 - Location of spill
 - Substance spilled
 - Estimated amount spilled
- Extent of spill
- Other pertinent information (e.g., injuries)
- Isolate the spill area and follow site specific procedures.

REPORT IMMEDIATELY TO:
MCCLELLAN FIRE DEPARTMENT
117 OR 643-6666

<u>SITE RESPONSIBLE INDIVIDUALS:</u>	<u>NAME</u>	<u>ORG. SYMBOL</u>	<u>PHONE NO.</u>
Unit Environmental Coordinator:	Steven Touchi	URSG	(916) 929-2346
Supervisor:	Chris Goodrich	URSG	(916) 601-5856
Alternate Supervisor:	Brandon Poteet	URSG	(916) 601-5889
Area Monitor:	Bo Patton	URSG	(916) 601-5867

OIL AND HAZARDOUS SUBSTANCE DATA (Indicate if Material (M) or Waste (W)):

<u>Description</u>	<u>Quantity</u> <u>(Amount/Unit)</u>	<u>Type of</u> <u>Container</u>	<u>Waste Stream</u> <u>No. (if any)</u>
Liquified Oxygen (LOx)	2 D45 containers	Cylinder	None

MSDS LOCATION: Inside ECOCHOICE Catalytic Ozonation Treatment Trailer

SITE SPECIFIC SPILL PLAN (continued)

FACILITY NO: Site IC 31

EVACUATION PROCEDURES:

1. Notify all personnel at Sites IC 29 and IC 31 to clear the danger area as necessary to avoid injury.
2. Shutdown all power to the Site IC 31 CatOx and ECOCHOICE treatment trailer.
3. Maintain the cleared area until the cylinder has completely exhausted the contents.

ON-SITE PERSONAL PROTECTIVE/SAFETY**EQUIPMENT:**

Protective gloves
Protective aprons or coveralls
Chemical goggles or face shields
Rubber boots
Full and half-face respirators

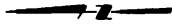
ON-SITE SPILL CLEANUP KIT:

Overpack Drum (absorbent storage)
Absorbent
Square point D handle shovel (spark free)
Disposal drum
Pushbroom

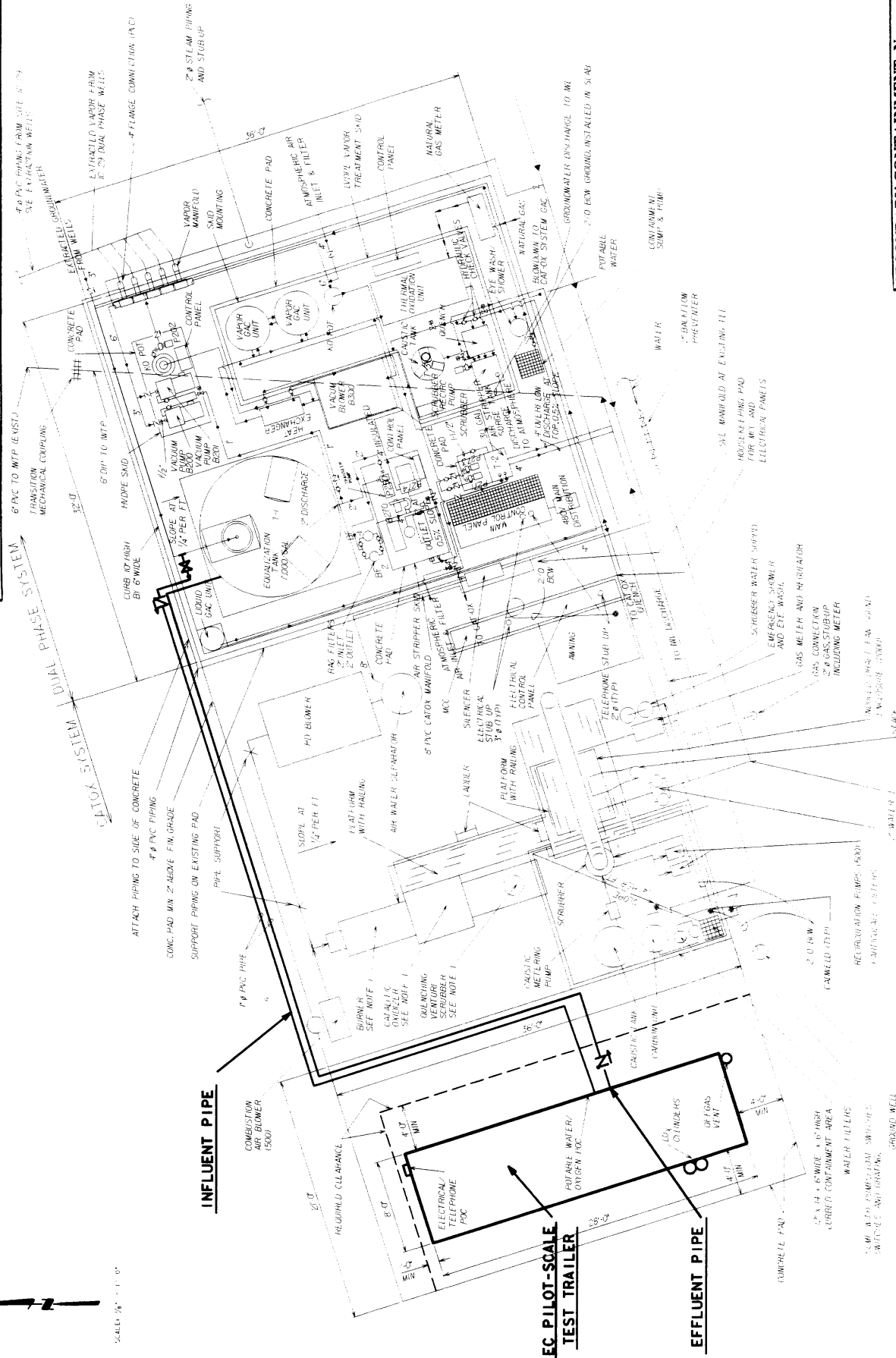
SITE SPECIFIC PROCEDURES:

1. Alert site supervisor and personnel, evacuate all personnel who are not equipped with personal protective equipment.
2. Notify base fire department, CEG, 117 (or 643-6666). Also notify the Maintenance Control Center, LAPRP, 3-3780.
3. Shut off power to Site IC 31 pad, eliminate ignition sources, eliminate all petroleum products
4. Wait until the D45 cylinder has completely exhausted the oxygen into the atmosphere.
5. Make spill scene off limits to unauthorized personnel.
6. If advised by the on-site commander, contain/cover spilled liquids with absorbent. Place absorbent, spill residue, and contaminated soil in a disposal drum.
7. Notify the Environmental Coordinate (UED)/LAPMS (3-5942) to participate in the chemical spill mishap reporting. Obtain from the UEC the recommended preventative action to be taken to avoid future spills. Assure with the UEC that the proper procedures are followed. Initiate AFLC Form 5023, Supervisor's Preliminary Report of Mishap Notification and Reporting, for all spills. Ensure all information has been provided and obtain UEC coordination.

SITE MAP



SCALE: 1/4" = 1' 0"



SECONDARY CONTAINMENT: None required